Programming Exercise 4:

Neural Networks Learning

（神经网络学习）

Machine Learning

介绍

在这个练习中，您将实现神经网络的反向传播算法，并将其应用于手写数字识别的任务。 在开始编程练习之前，我们强烈建议您观看视频讲座并完成相关主题的复习问题。 要开始练习，您需要下载初学者代码并将其内容解压到您希望完成练习的目录。 如果需要，在开始本练习之前，使用Octave / MATLAB中的cd命令切换到此目录。 您也可以在课程网站的“环境设置说明”中找到安装Octave / MATLAB的说明。

包含在这个练习中的文件

ex4.m - Octave / MATLAB脚本，指导您完成练习

ex4data1.mat - 手写数字的训练集

ex4weights.mat - 练习的神经网络参数4

submit.m - 提交您的解决方案到我们的服务器的提交脚本

displayData.m - 帮助可视化数据集的功能

fmincg.m - 函数最小化例程（类似于fminunc）

sigmoid.m – S函数

computeNumericalGradient.m - 数字计算渐变

checkNNGradients.m - 帮助检查渐变的函数debugInitializeWeights.m - 用于初始化权重的函数

预测。神经网络预测函数

[\*] sigmoidGradient.m - 计算sigmoid函数的渐变

[\*] randInitializeWeights.m - 随机初始化权重

[\*] nnCostFunction.m - 神经网络成本函数

\* 表示您需要完成的文件

在整个练习中，您将使用脚本ex4.m.这些脚本为问题设置数据集，并调用您将要编写的函数。您不需要修改脚本。您只需按照本作业中的说明修改其他文件中的功能。

1神经网络

在前面的练习中，你实现了神经网络的前馈传播，并用它来预测我们提供的权重的手写数字。 在这个练习中，您将实施反向传播算法来学习神经网络的参数。

所提供的脚本ex4.m将帮助您逐步完成这个练习。

1.1可视化数据

在ex4.m的第一部分，代码将加载数据并通过调用函数displayData将其显示在二维图（图1）上。

![图片包含 电子产品, 黑色, 键盘, 就坐

已生成高可信度的说明](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAwADAAAD/4RDmRXhpZgAATU0AKgAAAAgABAE7AAIAAAAJAAAISodpAAQAAAABAAAIVJydAAEAAAASAAAQzOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEhhbiBXYW5nAAAABZADAAIAAAAUAAAQopAEAAIAAAAUAAAQtpKRAAIAAAADNjEAAJKSAAIAAAADNjEAAOocAAcAAAgMAAAIlgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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这与您在上一个练习中使用的数据集是相同的。 在ex3data1.mat中有5000个训练样例，其中每个训练样例是该数字的20像素乘20像素的灰度图像。 每个像素都用浮点数表示，表示该位置的灰度强度。 20乘20的像素网格被“展开”为400维向量。 这些训练样例中的每一个在我们的数据矩阵X中变成单行。这给了我们5000×400的矩阵X，其中每行是手写数字图像的训练示例。

![图片包含 文字

已生成高可信度的说明](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAwADAAAD/4RDmRXhpZgAATU0AKgAAAAgABAE7AAIAAAAJAAAISodpAAQAAAABAAAIVJydAAEAAAASAAAQzOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEhhbiBXYW5nAAAABZADAAIAAAAUAAAQopAEAAIAAAAUAAAQtpKRAAIAAAADMTAAAJKSAAIAAAADMTAAAOocAAcAAAgMAAAIlgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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1hZWmNkZWZnaGlqc3R1dnd4eXqDhIWGh4iJipKTlJWWl5iZmqKjpKWmp6ipqrKztLW2t7i5usLDxMXGx8jJytLT1NXW19jZ2uHi4+Tl5ufo6erx8vP09fb3+Pn6/8QAHwEAAwEBAQEBAQEBAQAAAAAAAAECAwQFBgcICQoL/8QAtREAAgECBAQDBAcFBAQAAQJ3AAECAxEEBSExBhJBUQdhcRMiMoEIFEKRobHBCSMzUvAVYnLRChYkNOEl8RcYGRomJygpKjU2Nzg5OkNERUZHSElKU1RVVldYWVpjZGVmZ2hpanN0dXZ3eHl6goOEhYaHiImKkpOUlZaXmJmaoqOkpaanqKmqsrO0tba3uLm6wsPExcbHyMnK0tPU1dbX2Nna4uPk5ebn6Onq8vP09fb3+Pn6/9oADAMBAAIRAxEAPwD6RooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKK8stZ/HPinxl4pttI8XRaTZaTfrbQwnTYpiQYlbO489TQB6nRWfoVpqdjo0NvrmpDU75S3mXSwLCHyxI+ReBgYH4VoUAFFFFABRRRQAUUVDFdQTzzQwyB3gIWQD+EkZxn1xzj3HrQBNRRVHWdUj0bS5LyVGlIZY4ol+9LIzBUQe5YgUAXqKxNe8SR+GNEW+1W3mlwEEptUyqszKvcjjcw96s61qv9i28V7MgayWRUuXzzErEAP8AQE8+2T2wQDSoqKe6gtnhWeQIZn8uPPQtjOM/hVbV9SOl6f58du91M0iRRQIQGkZmAAyfTkk9gCaAL1FcvF4sv5/FFxoMWjI13bWkd3Kwu/kRXZlVSdn3jsY4x071t6NqJ1bR7a+a3a2M67jE7AlecdR1oAu0UUUAFFFFABRRWF4n0zxBqUFuvhnX10WRGJldrNLjzBjgYbpigDdorzjwxf8AizTvizP4Z8S+II9Ztjog1BGWyjg2OZ/Lx8vXgH869HoAKKKKACiiigAooooAKKKKACiiigArz/4d/wDI7fEH/sMp/wCiEr0CvP8A4d/8jt8Qf+wyn/ohKAPQKKKKACiqVzZXU05eHU57ZMf6tI4yB+LKTUX9m3//AEHLr/vzD/8AEUAaVFZv9m3/AP0HLr/vzD/8RVu0gmt42W4u5LpichpFVSB6fKBQBneLdbbw54Q1PVo0Ektrbs0KHo8nRF/FiB+NTaBpY0PQbayeTzJY03TzMeZZTy7n3LEn8awPispPw5vX/hiubOWT/cS6iZv/AB0Guh12602z0O6l125jtrDZsmkkfYoDHbgn3Jx+NAFf/hLNF88QG8xK6b40MTgzLkDMYx84yR93PUHoaxNb1ex1xPCWoaXdJc6dJrirJKh+U4inVQfpKEH1xVPMWr/Hc5KGDw1ov02TXL/0ji/WulGj6ZqfhaOysYPsdnIFmtxCgjMTBt6SKOxDAN9etAGH8XLu3t/hzex3FxFE8ktvsV3ALYuIycA9cCtXxlcWlz8N9fm8yOa1bTLnLowZWHltnBHWtuOFnto1vRFLKFG8hMKW7kA5wKqatpK6tBDaSuEsxKsk8QX/AFoUhgn+7kDI7jjoTQBFJph1jwmun6ruEs9qqyupwySbR8wPZg3IPqKpeEdd/tbwTZanrDxRXEW+G7diFVZonaKQ89MsrfnXR1x3w1Tf4f1WUjMFxr2pSw56FDdSDP5g0AU/hzeW2s+IPGGuxXEUr3mqfZ4gjgn7PboI0bHoW8wg9813iqqKFQBVAwAO1IkUcf8Aq41T/dXFOoAKKqXdpc3Eitb6hNaqBgrGkbAn1+ZTUH9m3/8A0HLr/vzD/wDEUAaVFZv9m3//AEHLr/vzD/8AEVZs7ae33/aL6W73Yx5iIu36bVH6+lAFmiiigDz9f+Tkn/7FJf8A0savQK8/X/k5J/8AsUl/9LGr0CgAooooAKKKKACiiigAooooAKKKKACvP/h3/wAjt8Qf+wyn/ohK9Arz/wCHf/I7fEH/ALDKf+iEoA9AooooAKKKKACiiigClrOlW2uaHe6VfLutr2B4JAOu1gQce/NZml2x1jw1/ZHii2S4ubcLDdrIuVmZSCsq+zbQw9Dx1FdBVW01C3vpbhbUmRbeTynkA+UuPvKD3IPB9Dx1BwAVT4a0gyLIbGIuq7C2OXXO7DH+IZ5571qDjpRWbr+rHR9LM8UYmuZZUt7aInAkldgqgnsMnJPYA0AaVFYVxrN1BqsWiWkcd1qIs/tUjTFokZd23ghSMlu3YY61m2/jdb3wbF4oghaG1tpnj1K2k5aEI5jlIYddhUtnoVB6HGADd12+ubLS3/s2Hz7+b91axn7pkI4LHso6k+g9SBR4e0aLw94dsdJt3aRLWEIZG6yN1Zz7kkk/WrF7qFvp6wvdkpHJII/Nx8qE9Nx7AnAz6kVFrN5dWdgDp1utxdyyJFDG5IXJPJYjoAuW/DFAF+iuQtvEOuXfjO/8PwxWBNhZw3M9xtfCvKzhY8Z64Qtn3HFdDol3dX+i2t1qEC29xKm540JIU57Z5oAvUUUUAFFFFABRRRQB5+v/ACck/wD2KS/+ljV6BXn6/wDJyT/9ikv/AKWNXoFABRRRQAUUUUAFFFFABRRRQAUUUUAFcB8PFI8a/EAkEBtZQjI6/uErv64D4ef8jt8Qf+wyn/ohKAO/ooooAKKpXOlxXU5lee7QkYxFdSIv5AgVF/YUH/P1qH/gdL/8VQBpUVm/2FB/z9ah/wCB0v8A8VVu0tEs42SOSaQMc5mmaQ/mxNAGR431mbQPBGq6jaEC6jgK2+ennOQkf/j7LV7SrC28PeH7ezVwsFnAA0rnGcD5nY+pOST7muf+Kyk/DfUJf4baa1uX/wByK5ikb/x1DW54j1bTNF8P3F9rnNiu1JAIzJu3sFA2gEnJYD8aAKcnjKxh1O20+a1vY7u9jaWziaIA3KqQG288YDKSG28H61jajrtn4ksPCWu6cZf7PGuKHMqFTzHPAuR/11dMH6VWS9tr7433l5dTJHaaFogiieQ4VpJpSZGU98CNVOOhOK7JrWDWtB8i8tWihuYwTCflZM8jp0YHB46EUAYXjbxT/Yfk2Nvbagbi8Q5u7PT5LgWydCflUjf6A8dz0wc8HTrX4I6ounafc2dimn3ccUF3GyzSnDruZW53O2TzydwPeu5gR4reOOWVpnVQGkYAFz6nHH5VW1DTItTNut0zNDDKsxh/hkZTlN3sGAOPUD0oAiXS0u/DCaVqqiZZLQQXAJzu+TDVk+CNalu/Adtc6tI8t1ZtLZ3TqhdnkhlaFm2gE5JTPHrXUVx/wzQnw5qF3/yzvta1C5i/3GupMH8cZ/GgCr8Oma81XxVq91b3MFzqOqsYxcW0kR+zRKsUR+YDqFLf8CruqKKACiql3p0d5IryTXUZUYxDcPGPyUioP7Cg/wCfrUP/AAOl/wDiqANKis3+woP+frUP/A6X/wCKqzZ2Mdlv8uW4k34z587yYx6bicdaALNFFFAHAKrf8NIO207f+ETUZxxn7W1d/Xn6n/jJJx/1KS/+lbV6BQAUUUUAFRXPn/ZpPsnl+fj5PMB2598VLRQBxPgbxnqniTXvEGl6zZWtjcaJci3kiidmZ8jKSc/wsM4rQ0jV/EGq63dFLSwXQ45ttveB2L3K9yq9MA8buhxkcYNee+MZINM+L2leIofNj0HWGXQ9XmRsJNJkmP8AAEBWb0BX1r2dEWNFSNQqqMAAYAFAC0UVz8lx4uEr+VYaSU3HaWuXyR2z8tAHQUVzv2jxj/0D9I/8CZP/AImt+Aym3jNwqrMUHmBDlQ2OcH0zQA+uA+Hgx42+IPvrKf8AohK7+vP/AId/8jt8Qf8AsMp/6ISgD0CiiigAooooAKKKKAK9/Y2+p6dc2N7GJba6iaGVD0ZWGCPyNZugWtzHoY0jWk+0PZqIDM65W5jHCv8AUgDcP7wPbFbVFAFb+zrM+T/osP7n/VfIPk+npVmiigAooooAzdee/wD7Le30cYvbn91FKR8sGRzI3+6OQO5wO+RLo+lW2h6LZ6XYKVt7OFYYweuFGMn1J6k1dooAKKKKACiiigAooooAKKKKAOAUf8ZIuf8AqU1/9K2rv68/X/k5J/8AsUl/9LGr0CgAooooAK5nxHH4pvbuKz0iCxj01pVF1M906zSRcblQBcIeozk8dMHp01FAHI/EPwk/if4d3fhzS7a2DTIqQeY5jW3KnKuMA9CBxxnnmtfwwutxaFbQeJltzfQxJHJNbyl1nIGC+Co2kntzWvRQAVz8ngbw9LK0kmnKWdizHceSfxroKKAOd/4QLw5/0DV/77b/ABrfghjtreOCFdscahEX0AGAKfRQAV5/8PP+R2+IP/YZT/0QlegV5/8ADv8A5Hb4g/8AYZT/ANEJQB6BRRRQAUUUUAFFFFABRRRQAUUUUAUdZ1nT/D2kT6prN0lpZW4BlmcHC5IUdOepA/GrkciTRJJEwZHUMrDoQehqlrdzpdno1xPr8lvFpyqPOa5x5YBIAznjqR+NXY2R41aIqyMAVKnII7YoAdRRRQAUUUUAFFFFABRRRQAUUUUAefqP+MknP/UpL/6VtXoFefr/AMnJP/2KS/8ApY1egUAFFFFABRRRQAUUUUAFFFFABRRRQAVwHw9GPGvxA5BzrKHA7fuErv68/wDh3/yO3xB/7DKf+iEoA9AooooAKKKKACiiigAooooAKKKKAKGtxaVNotxH4hFo2mso88XhXysZGN27jrjrV2MII1EeNgA27emO2Kq6vpFhr2lT6bq9rHd2dwAJYZBlWwQR+oB/CrUaLFGscahUQBVUDgAdqAHUUUUAFFFFABRRRQAUUUUAFFFFAHAqv/GR7tuGf+ETUbe//H23Nd9Xn6/8nJP/ANikv/pY1egUAFFFFABRRRQAUUUUAFFFFABRRRQAV5/8O/8AkdviD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训练集的第二部分是包含训练集标签的5000维向量y。 为了使Octave / MATLAB索引更加兼容，没有零索引，我们将数字零映射到值10。 因此，“0”数字标记为“10”，而数字“1”至“9”以其自然顺序标记为“1”至“9”。

1.2模型表示

我们的神经网络如图2所示。它有3层 - 输入层，隐藏层和输出层。 回想一下，我们的输入是数字图像的像素值。 由于图像大小为20×20，因此可以得到400个输入层单位（不包括总是输出+1的额外偏置单位）。 训练数据将通过ex4.m脚本加载到变量X和y中。

已经提供了一组已经由我们训练过的网络参数（Θ(1),Θ(2)）。 这些存储在ex4weights.mat中，并将由ex4.m加载到Theta1和Theta2中。 这些参数的尺寸是针对第二层中的25个单元和10个输出单元（对应于10位数类）的神经网络来确定的。

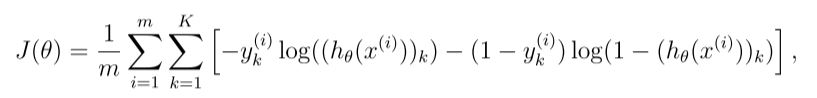
![图片包含 屏幕截图

已生成极高可信度的说明](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAwADAAAD/4RDmRXhpZgAATU0AKgAAAAgABAE7AAIAAAAJAAAISodpAAQAAAABAAAIVJydAAEAAAASAAAQzOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEhhbiBXYW5nAAAABZADAAIAAAAUAAAQopAEAAIAAAAUAAAQtpKRAAIAAAADMjQAAJKSAAIAAAADMjQAAOocAAcAAAgMAAAIlgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Twb4nPizQn1BrNrJ47qa1eF3DFWicoeRx1FUPDXiHUfGdpdatpM1vaaWLmW3sy8Jka4EbFDITuGAWDADngZ9q5Lwh4pTwf8ABzXNf1CESPb6vfHyY2+/K10yqgJ7FmAz6UAet1zmmeKpb3xzqfhu605raSyto7pJjIrCaN2ZQQB0+6eDWRqHinUdAi0e7vr2z1BLq8htb2C3jwYfNO0OhychWKg5HIyeOlGn/wDJfNa/7AFp/wCjpqAO6ooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKAPPPippGu6+3h2HQ9GkvF0vW7XU5pfPiRSke7KjcwO75h7V3dnI9zAlxcWbWs2CvlyFWZRn1Ukc4B6+lWKKAOH8Z2Os3njTwre6Zo815a6TdS3FxKs0S5DwtGAAzAkgtn6Vmaub/UPHWp3WgaEdYSGGOxmuYL/AOytE65ZoTkjeMOpyOQSRxXpdY//AAjsdvqF1eaXdz2L3j+ZcRx4aOR8Ab9pHDYA6EZx0zQBl+EdYhuorjw3Locvh+6063Q/YmKsvkvuVXRlJDDKsCeuRzXKf8I34htvgJceCodMZ9Ui0+W0D718qQZOGU5/iHQdQTzivRNN0K306+ub4yTXV9dKqS3M7AsUXO1BgABQWJwB35zWnQB5t4osPEGseCfDlpZeHrg3VpfWVzcRPcQr5awOrMMl8Enbxit7xr4bn8aeDBbRp9i1CGaK8tVnIYRzRvuUNtJBBwQcZ611dFAGFbT3t2bdV0X7BKHVrh5QjLGAckKVPzE9AR0zk+h3aKKAPN9fvfGkvi15IPBP9p6bYyf6Dv1GKNWYf8tipPX+7np169N7Tr/xbJ4T1TULvRYodZZ3ez0x7pWUAIoVTIOOWDN/wLFdVRQBBYSXMunW0l/CsF08StPEjbhG5A3KD3AORmpZXaOF3RDIyqSEUgFj6DPFOooA5vwnPq7Saimr6JNpqyXck0LvPFIHRiMD5GOD/nNZUPgWbS/i5/wkmkv5em38Ejahag4AuQAFlA9WUsDjuM967migDirbw9ceHPHWt6tb2P2/Ttc8qaVUAMltOi7CcHqrDB45BB7VZ8T6FqHif4ea/pKxRWk+oW8kdrCcDZ8oChyOMlgTx0BHpXWUUAebeNbPxBrfhXQ4NO0OYz6fqNld3MLugZhE4LKhzgnjrnHFXPEttrt9488JavZaBcTWulfaJLn9/CrAzQbAoBfkgnntxxmu9ooA4/x5pOq6wmiGyha40+3vlm1OxSQK1xEFOF64YBiCVz82Mc1mXmh6yvxAstc0TS0t7NdHn0yJAUQ27s6OsrJ/c+XoOeOnIr0OigDhtBsdag+K3iDVbvRpoNP1K3tYYbgzRHBhEmSVDE4O8Y4+uK7hiQpIGSB0HelooA4Hwdaa7pXiDxbe6hoFxFFqd8Ly2xcQsWAiRNpw/BJUnnj3rD0vwHrGq/Ce88N6rYnS9Qj1CTULOWWRJEMhuGmTOxjxyFP1OM161RQBg2s9/dC2T+xBYTh1Nw8uxkjAILBSD8xOCAR0zk+lYU2iaxp3jvxPqFjbtLFr+n28UE8bAfZ5olkT5s84xIGz7Eda7uigDj/iH4e1PWLPSb7w4VTWNJ1COe3dumxv3coPtsck/wC7VV/BtzZ/EKwutLVV0Wawjh1BS3Je1YNbn3J3EH2Su6ooA5HUNAutP+I8Xi7ToDdpPp/9n3tsjAOFD70kXPBxyCOuCMZqNdEvNS+ICeLLyzkhi03T5LWxtCy+ZM7tl3POF4AUAnuScV2VFAHEfDiw1nSV1yDWdIlshe6xeajFI00TgpLJuVTtYkNg/Tis2fwnNr3xE8QzeIPDjvpGqadDYx3DyxEp5ZkLMAGLLncuDjOR2r0migDkfh7L4ni0NdO8X6dLFcWeY4r15o3+0xg4QsFYkPtxntnvXUXk0tvaSSwWz3UijKwxsoZ/YFiB+ZqaigDyvQ9B8R6f8A7vwrcaDL/ar2V1aJGLiEqxm80ht2/GBuGe/oKl8TaN4i1T4M6f4etNBmOoolnHJGbiEBPIkiZju34IOw4x+OK9PooA4y70W+i8eWPjSzsZGkk01tNvrEuvmKnmeYjqc7SQ2QRnkNxnFSR6Fda38RrLxNf27WltpVnLb2UMhG+SSUjfIQOgCqAAeeT0wM9fRQBxPgzR7/wLpM/h5bGS8sYbqWXT5oWXmORy+x8n5WUsRk8EYrm9I8DatrXwu17wprtk2mXU+oT3dtcl1eNmacyxkYOcZAzkDivWqKAOetJ9Sube3ik0RbK9yv2iVgjRR4I3FSDls84+ozisewsdaT4xajrE2jTR6bc6dDZJcGaI/NHJIxYqG3YIcY4zXc0UAZWj3Ws3F7qiazp8Npbw3JSxkjmDmeHA+dh/Cc9q1aKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigD/2Q==)

1.3前馈和成本函数

现在您将实现神经网络的成本函数和梯度。 首先，完成nnCostFunction.m中的代码以返回成本。

回想一下，神经网络（没有正则化）的成本函数是



其中hθ(x(i))如图2所示计算，K = 10是可能标签的总数。 注意，hθ(x(i))k = a(3)k是第k个输出单元的激活（输出值）。 另外，请记住，尽管原始标签（在变量y中）是1,2，...，10，为了训练神经网络，我们需要将标签重新编码为仅包含值0或1的向量，所以那

![图片包含 时钟, 物体

已生成高可信度的说明](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAwADAAAD/4RDmRXhpZgAATU0AKgAAAAgABAE7AAIAAAAJAAAISodpAAQAAAABAAAIVJydAAEAAAASAAAQzOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEhhbiBXYW5nAAAABZADAAIAAAAUAAAQopAEAAIAAAAUAAAQtpKRAAIAAAADMTgAAJKSAAIAAAADMTgAAOocAAcAAAgMAAAIlgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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1XP3h7ir9cB8V7j+x9J8P6tbDy5bHXLQKUGP3bt5bp9CrEY+ld/QAVwHi4kfGn4djPBTVM/9+Erv64DxapPxo+HjDoqannn/pglAHf0UUUAFFFFABRRRQAUUUUAc3431WXRfDt5qLTPb2dnaTXE0sZw7MoGyMem5j19sd6xtV8Qa9Y+GvBdpI6R69rN5aQXeEB2gJ5lwQPZUYfjWh8SLO21jwuuhS3sNtdalcxLaxy5xcPHIsvl8diIyCe2ayIWvvEXxstmurdI7Tw3pzviN94W5uCFClumRGpOOwYetAHolYE0/isXEgt7TTWi3HYWkfJXPGffFb9YE/gjw9cXEk02nI0kjF2O9uSTk96AGfaPF/8Az5aX/wB/XrdtjObWI3aos5QeYEOVDd8e1YX/AAgXhr/oGJ/323+NbttbRWdrFbW6bIokCIo7AcAUAS15/wCCf+SsfEf/AK+rH/0lWvQK4DwT/wAlX+I3/X1Y/wDpKtAHf0UUUAee/D5ofBWgaroesN9mbTdQuZYdyn99BI5kRk/vcNjA5yK0PhXot3ovgaP+0oTBeX91PfyxN1jMshYKfcKVz7117wxSMrSRo7L90soOKfQAVheOP+Se+Iv+wXc/+imrdrC8cf8AJPfEX/YLuf8A0U1AEPw7/wCSX+Fv+wNaf+iUro65z4ecfDDwt/2B7T/0SldC+7y28sgPg7SemaAHUVheDrnWbjw+B4le3l1GGaSGWW2XbHJtYjIHt0+oNbtABRRRQAV5/wDD7/kfPiF/2Fov/SdK9ArgPh9/yPnxC/7C0X/pOlAHf0UUUAed/DqWDwP4IudA1gmCXRbq5CKVOZ4mlaSNkH8WQ4GB3GK1PhVoV34e+HOn2upxeVezNLdTx90aWRn2n3AYA/SuteGKR1d40Zl+6xUEin0AFc18SP8Aklfiv/sDXf8A6JaulrmviRz8K/FX/YGu/wD0S1AFvwZ/yIegf9gy2/8ARS1tVi+DP+RD0D/sG23/AKKWtecSm3kFuVEuw7CwyA2OM+2aAH0VieD7nVrrwzA3iJ4JNSjklinkt1wjlJGXIH4Vt0AFFFFABRWVdR62fFFg9pNbLoywyC7jdMytJxsKnsKsayuovol4uhyQx6iYmFs8y5RXxwSPSgC7RVewF0um2w1Fo3uxEonaMYUyYG4gemc1S02PW113VW1Sa2fTWaP+z0iTDoNvz7z35xigDVooooAK5Xxf4iuNO1fw9oOnOIr3Xbt4lmK58qKNDJIwB6nAAH19q6qud8VeGW1u60jU7KRItT0W6+0WrOMqwZSskbezKevYgUAZ+v6vP4M1fw+zXU11p+raimmSxztvZJZFYxurdcblwR0+bNY9s/iTUfHnjDw9ba7LHDa2ltNaTugJgklWTA46rlcn12gVvan4fvfFOtaNca1DFaWWj3Yvkt0k8xprhVIQk4GFXcxx3OKr6LouvWPxI1zXLm2tfserR20IVZiXiEIcbunOd/SgDr7VJo7OFLqQSzrGokkC4Dtjk47ZNS0UUAFFFFAHJ/FP/kkvin/sFz/+gGtnwz/yKWkf9eMP/osVjfFPn4S+KP8AsFz/APoBrZ8M/wDIpaR/14w/+ixQBp1xfxS0e51PwtaXVhC1xcaPqdrqawoMs4ikBYAdztLce1dpRQB5948EXjGLw7o+juLnztVt7y5ZRxFbxHexb+6SQqgHnJ9jXoNMSGKJmMcaIW6lVAzT6ACvP/F3/Javh3/uap/6ISvQK4DxcP8Ai9Pw7/3NU/8ARCUAd/RRWVrUetvcaYdCmtoolu1N+J0yXgwdwX0bpQBq0UUUAFFFFABRRRQBS1DSbXU2ge4DCW3cvDLG214yRg4PbIp2naXZ6TbtDYwiNXcu56s7HqzHuat0UAFFFFABRRRQAV5/4J/5Kx8R/wDr6sf/AElWvQK4DwT/AMlX+I3/AF9WP/pKtAHf0UUUAFFZeq+ILTSNT0uxuo7hpdUmMMBiiLqrBc5cj7o961KACsLxx/yT3xF/2C7n/wBFNW7WF44/5J74i/7Bdz/6KagCH4d/8kv8Lf8AYGtP/RKV0dc58PP+SX+Fv+wPaf8AolK6OgCK2torS2SC3XbGgwBUtFFABRRRQAV5/wDD7/kfPiF/2Fov/SdK9ArgPh9/yPnxC/7C0X/pOlAHf0UUUAFFZepeILTS9a0rTLiO4afVHkSBooiyKUXcd7fw8HitSgArmviR/wAkr8V/9ga7/wDRLV0tc18SOfhX4q/7A13/AOiWoAt+DP8AkQ9A/wCwZbf+ilraIyCKxfBn/Ih6B/2Dbb/0UtbVAEdvbxWltHBboEjjUKqjsKkoooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigDk/in/ySXxT/wBguf8A9ANbPhn/AJFLSP8Arxh/9Fisb4p/8kl8Uf8AYLn/APQDWz4Z/wCRS0j/AK8Yf/RYoA06KKKACisvR/EFprd1qVvaR3CPpt0bWYzRFAzgZypP3hz1rUoAK8/8Xf8AJavh3/uap/6ISvQK4Dxd/wAlp+Hf+5qn/ohKAO/ooooAKKKKACiiigAooooAKKKKACiiigAooooAK8/8E/8AJWPiP/19WP8A6SrXoFcD4KAHxW+IuDkm6scjHT/RVoA76iiigDM1TXtN0nUtMstQkKXGpTGG1AQtucLk89uK06zdT1jSdO1HTbXU54Yrq+mMdkki5LuBkheODitKgArC8cf8k98Rf9gu5/8ARTVu1h+N8H4feIcnA/su5yf+2TUAQfDv/kl/hb/sDWn/AKJSujrnfh6APhj4XCnI/se0wcdf3KV0VABRRRQAUUUUAFef/D7/AJHz4hf9haL/ANJ0r0CuA+H4A8d/EHByTq0WRjp/o6UAd/RRRQBmajr2m6ZrOl6bfSFbvU3kS0XYTuKLlue3BrTrN1DWNJsNX0yx1GeGO+v3dbGN1y0jKuW2nHHBrSoAK5r4kf8AJK/Ff/YGu/8A0S1dLXN/EcA/C3xSGOB/Y93k46fuWoAteDP+RD0D/sGW3/opa2qxfBv/ACImgY5H9m2//opa2qACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKAOT+Kf/JJfFP8A2C5//QDWz4Z/5FLSP+vGH/0WKx/ikAfhP4oDHA/syfJxnHyGtjwz/wAinpH/AF4w/wDoAoA06KKKAMzSNe03WbrUoNNkLyaddG2ugUK7ZABnr1+tadZuk6xpOqXOoxaTPDLLZXJgvBGuCkoHIbjk1pUAFef+Lv8AktXw7/3NU/8ARCV6BXA+LQv/AAuj4eEtghNTwMdf3CUAd9RRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAV5/4J/wCSsfEf/r6sf/SVa9Arz/wT/wAlY+I//X1Y/wDpKtAHoFFFFAEU1pb3EsMs8MckkDbomZQShxjI9OKlrOu9f0uxuHgurtEkjAaRQC3lg9C2B8v44q+jpLGskTK6MAyspyCD3BoAdWF44/5J74i/7Bdz/wCimrdrC8cf8k98Rf8AYLuf/RTUAQ/Dv/kl/hb/ALA1p/6JSujrnPh3/wAkv8Lf9ga0/wDRKV0dABRRRQAUUUUAFef/AA+/5Hz4hf8AYWi/9J0r0CvP/h9/yPnxC/7C0X/pOlAHoFFFFAEUtpbzzwzTQxySwEmJ2UEoSMHB7cVLWddeINLsriSG5vER4gDKMEiPPTcQML68445rQVldQyEMrDIIOQRQAtc18SP+SV+K/wDsDXf/AKJaulrmviR/ySvxX/2Brv8A9EtQBb8Gf8iHoH/YMtv/AEUtbVYvgz/kQ9A/7Blt/wCilraoAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooA5P4p/8AJJfFP/YLn/8AQDWz4Z/5FLSP+vGH/wBFisb4p/8AJJfFP/YLn/8AQDWz4Z/5FLSP+vGH/wBFigDToopHdY1LOwVR1JOAKAI4LS3tnla3hjiaZ/MkKKAXb1PqalqnY6tp+py3Een3kNy1q4SYROG2MRnBI74q5QAV5/4u/wCS1fDv/c1T/wBEJXoFef8Ai7/ktXw7/wBzVP8A0QlAHoFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABXn/gn/krHxH/AOvqx/8ASVa9Arz/AME/8lY+I/8A19WP/pKtAHoFFFFAHAfCCcax4LvdXugJJtV1S8lmLjOR5rIq/QKoGKf8HL2S48ByWkjs40zUruxjLHnYkrbB+CkD8Kh8ANF4J0HVtD1gm3On6hcywZUnz4JHMiMmPvH5iMDnIrR+Fmh3eh+BoxqcRgvL66nvpoj1jMshYKfcKVB96AOxrC8cf8k98Rf9gu5/9FNW7WF44/5J74i/7Bdz/wCimoAh+Hf/ACS/wt/2BrT/ANEpXR1znw7/AOSX+Fv+wNaf+iUro6ACiiigAooooAK8/wDh9/yPnxC/7C0X/pOlegV5/wDD7/kfPiF/2Fov/SdKAPQKKKKAPPvg3Kut/DCPVrxRLNrN3eXFyXGd+biRQD7BVAx6Cpvgzfy3vwwso7iRpHsp7izDsckrHMyp+ShR+FVvh5JD4G8FXXh/V90MmjXVyI12EmeF5WkjZB/FkPjA5BFavws0G78O/DrT7TU4/KvpWluriP8AuPLI0m0+4DAfhQB19c18SP8Aklfiv/sDXf8A6JaulrmviR/ySvxX/wBga7/9EtQBb8Gf8iHoH/YMtv8A0UtbVYvgz/kQ9A/7Blt/6KWtqgAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigDk/in/AMkl8U/9guf/ANANbPhn/kUtI/68Yf8A0WKxvin/AMkl8U/9guf/ANANbPhn/kUtI/68Yf8A0WKANOo7i3iurd4LiNZInGGVuhqSorm4jtLZ55yVjjGWIUsQPoOTQBwXw4ijg8afECOFFRF1eMKqjAH+jpXoVeZ/D3VbceOvGnmJcxjUNVjktWktZFWVRCqkglcYyp616ZQAV5/4u/5LV8O/9zVP/RCV6BXn/i7/AJLV8O/9zVP/AEQlAHoFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABXn/AIJ/5Kx8R/8Ar6sf/SVa9AritY+FHhrW/EF5rN2L+O8vShna3vZIlcqoQcA46AUAdrRWZ4f0Cz8NaQmm6c07QIzMDPM0rZJyfmPNadADXijkZWdFYr90kZxTqKKACsLxx/yT3xF/2C7n/wBFNW7XA3nwa8LX8k73L6q32gsZF/tGXad3UYz056UAbfw7/wCSX+Fv+wNaf+iUro6q6Xp1vo+kWemWKlLaygS3hUnJCIoVRnvwBVqgAooooAKKKKACvP8A4ff8j58Qv+wtF/6TpXoFcRqnwl8M6trl7q1wNQiur5xJObe9kjVmChQcA46AUAdvRWdoOh2nhzRodM08zNbwlipnlMj/ADMWOWPJ5NaNADWijdlZ0VmX7pIyRTqKKACua+JH/JK/Ff8A2Brv/wBEtXS15/c/BbwpeCYXLaq6TZEiHUZdrA9RjPSgDpvBn/Ih6B/2DLb/ANFLW1UFhZQ6bpttY2ilYLWJYYgTkhVAA5+gqegAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigDk/in/wAkl8U/9guf/wBANbPhn/kUtI/68Yf/AEWKm1jSbXXdFvNK1FGe0vIWhmVW2kqwwRntXI2Hwe8Madd21xayaoGtnV41bUZSoKkEAjOCOOlAHd0UUUAFFFFABXn/AIu/5LV8O/8Ac1T/ANEJXV+IvDtl4o0r+z9Ta4WDzBJm3maJsjp8y845rB0T4V+G9A8QWutWQvpL20DiFri8eUJvXa3DHuDQB2dFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFAH/9k=)

例如，如果x(i)是数字5的图像，那么对应的y(i)（应该与成本函数一起使用）应该是一个10维向量，y5 = 1，其他元素相等为0。

您应该实现计算每个示例i的hθ(x(i))的前馈计算，并将所有示例的成本相加。 你的代码也应该适用于任何大小的数据集，并且可以使用任意数量的标签（可以假设总是至少有K≥3个标签）。

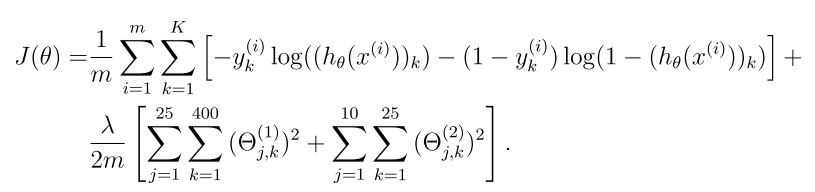
实现注意：矩阵X包含行中的例子（即，X（i，:)'是第i个训练样例x（i），表示为1×n向量）。当你完成nnCostFunction.m ，您需要将1的列添加到X矩阵。 神经网络中每个单元的参数在Theta1和Theta2中表示为一行。 具体来说，Theta1的第一行对应于第二层中的第一个隐藏单元。 您可以对示例使用for-loop来计算成本。

一旦你完成了，ex4.m会使用Theta1和Theta2的加载参数来调用你的nnCostFunction。 你应该看到，成本约为0.287629。

你现在应该提交你的解决方案。

1.4正则化成本函数

具有正则化的神经网络的成本函数由下式给出



您可以假设神经网络将只有3层 - 输入层，隐藏层和输出层。 但是，您的代码应该适用于任意数量的输入单位，隐藏单位和输出单位。 虽然我们明确地列出了上面的Θ（1）和Θ（2）的索引，但是请注意，您的代码通常应该适用于任何大小的Θ（1）和Θ（2）。

请注意，您不应该规范与偏见相对应的条款。 对于矩阵Theta1和Theta2，这对应于每个矩阵的第一列。 您现在应该将正则化添加到您的成本函数中。 请注意，您可以先使用现有的nnCostFunction.m计算未经调整的成本函数J，然后再为正则化项添加成本。

一旦你完成了，ex4.m将使用载入的Theta1和Theta2参数来调用你的nnCostFunction，并且λ= 1。你应该看到成本约为0.383770。

你现在应该提交你的解决方案。

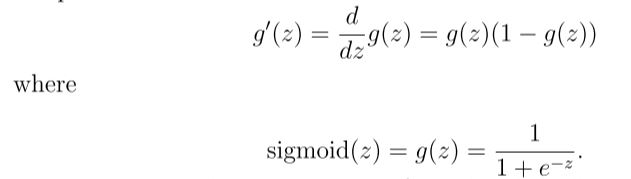
2反向传播

在这部分练习中，您将实施反向传播算法来计算神经网络成本函数的梯度。 您将需要完成nnCostFunction.m，以便它为grad返回适当的值。 一旦你计算了梯度，你将能够通过使用高级优化器如fmincg最小化成本函数J（Θ）来训练神经网络。

您将首先实施反向传播算法来计算（未经调节的）神经网络参数的梯度。 在你证实你的非正则化情况下的梯度计算是正确的后，你将实现正则化神经网络的梯度。

2.1 Sigmoid梯度

为了帮助您开始练习的这一部分，您将首先实现sigmoid梯度函数。 sigmoid函数的梯度可以计算为



完成后，尝试在Octave / MATLAB命令行调用sigmoidGradient（z）来测试几个值。 对于z值较大的值（包括正值和负值），梯度应接近于0.当z = 0时，梯度应恰好为0.25。 你的代码也应该处理矢量和矩阵。 对于一个矩阵，你的函数应该对每个元素执行sigmoid梯度函数。

你现在应该提交你的解决方案。

2.2随机初始化

在训练神经网络时，随机地初始化对称破缺的参数是很重要的。 随机初始化的一个有效策略是在[-init，init]范围内随机选择Θ（l）的值。 你应该使用init= 0.12.2这个值的范围确保参数保持很小，使学习更有效率。

你的工作是完成randInitializeWeights.m初始化Θ的权重; 修改文件并填写以下代码：

![图片包含 屏幕截图

已生成极高可信度的说明](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAwADAAAD/4RDmRXhpZgAATU0AKgAAAAgABAE7AAIAAAAJAAAISodpAAQAAAABAAAIVJydAAEAAAASAAAQzOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEhhbiBXYW5nAAAABZADAAIAAAAUAAAQopAEAAIAAAAUAAAQtpKRAAIAAAADMTMAAJKSAAIAAAADMTMAAOocAAcAAAgMAAAIlgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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DZH/AOCtP/iqP7G8U/8AQ2R/+CtP/iq6SigDm/7G8U/9DZH/AOCtP/iqP7G8U/8AQ2R/+CtP/iq6SigDm/7G8U/9DZH/AOCtP/iqP7G8U/8AQ2R/+CtP/iq6SigDm/7G8U/9DZH/AOCtP/iqP7G8U/8AQ2R/+CtP/iq6SigDm/7G8U/9DZH/AOCtP/iqP7G8U/8AQ2R/+CtP/iq6SigDm/7G8U/9DZH/AOCtP/iqP7G8U/8AQ2R/+CtP/iq6SigDm/7G8U/9DZH/AOCtP/iqq6v4U1/W9JvtMvvFKmzvoJLeZE01A3lupVgDu4OCea66igAooooA/9k=)

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2.3反向传播

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已生成高可信度的说明](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAwADAAAD/4RDmRXhpZgAATU0AKgAAAAgABAE7AAIAAAAJAAAISodpAAQAAAABAAAIVJydAAEAAAASAAAQzOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEhhbiBXYW5nAAAABZADAAIAAAAUAAAQopAEAAIAAAAUAAAQtpKRAAIAAAADMjIAAJKSAAIAAAADMjIAAOocAAcAAAgMAAAIlgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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oFxayanGbeW71B4ljgjbhmwjsWOM4GBz3oA3NS1Kewj0S00O3ea1vXERvI1EiW0QjLBzyODgAHkexqn4b8Vyah4s1nw9dTW10+nxQ3EN3bH5ZYpNwwwBIDKyEHHByOBWPqfhO/sX8G6bHFNqvhzSLcwXtsjANK6xqsUjKSA6ggnGeCQcGnWuj63b/E691a20vydP1KxtbZG3J+4WKUmQSLngsjNt257ZxQBa0jxVq3ifwzfeJtGVF0+Mzf2fbLD5kl4sRK7jlh95lO0DHbJOazdb1VR8R/AGq6ug0wHSdRnuEuHA+z5jgLKx6cdPwrQ8DabqXgXw9/wjEunXF7b2M0v2C6gZNssLuXUPlgVYbiDwRwDntVTxDpOpar8RPDF1qHh6XULLTrW6iu5l8oxF5liwVVnBIG1gcjP1oA6DQ7zxNqr3V7PJpcWlzbm03ZbyGV4yMxvIfMx74ABI/u9Bk+Dtd8U+JrPWhcT6bbzaZqtzp6yR27lZTEQAxUvwPbJPuKPAltrfhvUr/w1c6VdtoFvOf7Iv5JY22QkZ8thu3bVbIU4JxjOMVnfDfUbmyj8YhdMuLtP+Eo1Axm3KEsd4+UhiMH36fSgCe68f6pd/DTXtZ02K0s9Y8OyXEWoW1wjSx74VJYIQynDDBBPY9DWrbeI9ZtdP/4SLXEs4fD40g30uzcJ4nADBcdD8mc+/ArnJvB+s2Pwv8Wwmxa913xVLdTyW9s67bdpkKom5iuVUAAnqSeldUNHfxN8M5dA1W0uNNe40/7FIspQsp8sLuG1iCAfftQBFHrHiCXwYPEyrbBmtPtq6aUP+r27whfOd+OM9M9qzNd8c6n5Hg/VfDLWU2meIruG28u4ibzF8xHfduDYGAuCuOueatRHxBD8P18P/wBkSNqyWP2EXAdPs5YJsEu7O7b3xtz29657xVof/CJeHfhpo1gPtR07XrWIZO3zSIJtx9iTk0AdVq3iTUfCuuaNFrbW9zpur3QsVnhjMbW9wwJQEEkFGwR6g45Oamu9Y1SXV9XtUMekw6eIhbXV7GDDeM6bvvbgcA/KQMH35wM/xLo9/wCNda0C2eymsdL0vUI9SuZbgrulkjB8uJApPGTlicdOM5qLSdM1Sz8ZeINQ13S5NTuZroHSroOpiittoCxDJzGQ24sQOc55oAd/wspP+FMf8J0bHLeRk2ofjzfM8rG7+7v7+lP1bW/EOneJtF8PyXdp5uuQ3BiuorY/uJoUD42liChB788deQRzOnaXq3hz4Qy+Gtbsoy6+bZxQOVKalLLcu6ohBJAZDjJxtyT/AA5q/DrE/hqePWvEHgnVLe3tITE1++oreGzhONx2k5C8DcV5wvPSgDq7vVdUXXm0yTFjbw2C3MmpvEPJeUsVMYLNxjAOOSQeoxzV8MeJb/xd4Tv5bWS1tNTs7yewkmVDLD5kTbS6DPIIwQCT171SfTNQPxN1DVdY0+XVtMNtANHMTIyWpAPm5VmGGZsENzwMZFJ4B0fXdFv9btdTsxBBd6rd6h5qOrRuJtjIq/xZU7wcgdPegCL4NTazefDTRb3ULy2mhuLd5MCFhKXaRiSz7yDzn+EdasaF4yvIV8ZSeKXtfJ8OXBDTWkRQPGIVlJ2ljz82OtM+HWk6zoHhPRPD19aSwNpBlW4mDKY7hRvCbMHJzvVuQMbcVn6Z4av9bm8fafrWk3mnWfiOQtBcSNE21fISLkK5IbK5A6Y70Ab0WseIJvBg8TItsGa1+2pppQ/6vbvCF85344z0z2rM1/x5qEdj4Q1rw39ludL8QXlva+TNGRLmVHYHeGwMbQCMHHP0q1CfEEHw/Xw//ZEjatHY/YVuA6fZywTYJd2d23vjbnt71i634T1DRvD3gTQdC0u61OLw/qNrd3FxG0ahkjSRXwGcHcS2cdMHrQB00niDUtM+IGk6BqJt7iDV7S4mikijKNFJDsJHU5Uh+O4I6murrgteg1a6+KfhfVrbQr6Sx023uo7iUPCMGdI9uAXycFSD+ma72gDzTxf/AMnAfDv/AK99S/8ARIrsvF//ACJ2qf8AXs/8qx/Gvhy9u9f8O+KNGiFxf6DPKTbFgv2iCVNkigngMBgjPGRjjOau3l1ceJbddOt9Ou7W3ldDdzXSBAsYILIBklmbG3jgAk54wQCl8RfEOteGNMsL/RfsciSX9vazQ3EbbnEsgT5WBwvXuDS+JPEmqeDUstT1hrW60ma5jtrxoojG1r5h2rIMscqGIBB55yD2qh8ZDIvgyxMCq8g1qwKKxwCftC4BPapvG2k6h470218OrYTWWnzXUU2o3FwV4ijcP5aBWJLMyrzwAPXpQBp3niS4uvHB8L6L5Sz29oLy+uZVLCFGbaiKoIy7YJ54AHQ5rC0z7WP2gr9L9ondPDMAR4gRvX7TIckHockj8M98VozaHeaL8TrjxPY2z3lnqljHa3kURHmRSRsSkgBIBUqSCOowDzVG1g1n/hdsusy6FdLplzosVklwJIz5brM7neN2Rwf4d3b1IABa1TxPq9vpeu6iFh006XNMlrbX6BVvljXduDbskN2IxjuDisb4n67far8ArjXtEuFsob7Top5EePc7RTbMoDkAcOQTg/hUmkeH9YGkeIbbWtNa58QajLcxpqcjK0RifIiwc7lRVIGwDqD65qCXwp4h1j4EzeFZrUWd5DpFtZwwzMp3zQgbm3KT8rbVAzz7CgDsNY16fwh4S1PXPEs9vcRWURlAtIWi3dgvzM3JYgD61hX/AI2vdC0TT9Z1O+024SaeCO+srdhm3WVggKHcSxUsM56jOMVc8RaDdfEDwlrWlX8M+mwahZRRQxzlS0U6szlsKSCN3ljrztPsavWN3qs+lwW11on2fUtqpNK2xoFYY3OCDlh1IGAegOOtAGbB42TUda1fTI9YsNM1Kwumt4NPu8K0uANrtkgsrZyNmOCK6zSZbqfRbKXUYxFeSW8bToOiyFQWH4HNcXe6DDr9rqEPjLwiupTC6uFs7hFjLtAZG8v5iQUYLj8MHOcgaunr4j0DQPC2mLaJq0qrFbapdPPtMKhMGQZ5fkfU/jwAdVRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFABWZq2h2+rT2ly0ktveWTs1tcwkB49www5yCCOoII4HoK06KAMSfw3/aE1s2sahcX0VtMk8cDqiIZEOUZgqjdggEA8ZAOMgVt0UUAFFFFABRRRQAUUUUAFFFFABRRRQAUUUUAFFFFADJkaSF0jkaJmUhZFAJQ46jORx71geFfCKeFWv/ALPqd5dpqF1JeTJcCPHnSHLuCqgjOOnT2roqKACiiigArnPE3hBfE99ptzNqt5af2ZcLdW8duI9omUMA53KSeGIx09q6OigBqKVjVWYuQACxAy3vxTqKKAM/WdGtdcs0t7zepilWeGWNtrxSKcq6nsR+oJB4NUb7wy+rWT2OsardXdlKNs1uUjQTr3Viqg4PcAjI4PFb1FACABVAUYAGABS0UUAFFFFABRRRQAUUUUAFFFFAHP8Ai3wlH4utLe1utRu7SGCdLgJbBPmkRgyEllJ4I6dK3LeN4reOOWZp3VQGlcAFz6kAAfkKkooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooAKKKKACiiigAooooA/9k=)

现在，您将实施反向传播算法。回想一下，反向传播算法背后的直觉如下。给定一个训练样例（x(t)，y(t)），我们将首先运行一个“正向传递”来计算整个网络中的所有激活，包括假设hΘ(x)的输出值。那么，对于第l层中的每个节点j，我们想要计算一个“误差项”δ(l)j，用来衡量节点对我们输出中的任何错误“负责任”的程度。

对于输出节点，我们可以直接测量网络激活和真实目标值之间的差异，并用它来定义δ(3)j（因为第3层是输出层）。对于隐藏单元，您将根据层（l + 1）中节点的误差项的加权平均值计算δ(l)j。

详细地说，这里是反向传播算法（也在图3中描绘）。您应该在一次处理一个示例的循环中执行步骤1至4。具体来说，应该实现一个循环为for t = 1：m，并将下面的步骤1-4放在for循环中，第t次迭代在第t个训练样例（x(t)，y(t)）。步骤5将累积梯度除以m以获得神经网络成本函数的梯度。

1. 将输入层的值（a(1)）设置为第t个训练样例x(t)。 执行前馈过程（图2），计算第2层和第3层的激活（z(2)，a(2)，z(3)，a(3)）。注意，您需要添加+1项 确保层a(1)和a(2)的激活向量也包含偏置单元。 在Octave / MATLAB中，如果1是一个列向量，则加1对应于a\_1 = [1; a\_1]。
2. 对于第3层（输出层）中的每个输出单元k，进行设置



其中yk∈{0,1}表示当前训练样本属于类k（yk = 1），还是属于不同类（yk = 0）。 你可能会发现逻辑数组对这个任务有帮助（在前面的编程练习中解释过）。

1. 对于隐藏层l = 2，设置

图片包含 物体, 剪贴画

已生成高可信度的说明

1. 使用以下公式累积此示例中的梯度。请注意，应跳过或移除δ(2)0。 在Octave / MATLAB中，删除δ(2)0对应于delta\_2 =delta\_2（2：end）。

![图片包含 物体

已生成高可信度的说明](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAwADAAAD/4RDmRXhpZgAATU0AKgAAAAgABAE7AAIAAAAJAAAISodpAAQAAAABAAAIVJydAAEAAAASAAAQzOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEhhbiBXYW5nAAAABZADAAIAAAAUAAAQopAEAAIAAAAUAAAQtpKRAAIAAAADOTMAAJKSAAIAAAADOTMAAOocAAcAAAgMAAAIlgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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1. 通过将累积梯度除以1 / m得到神经网络成本函数的（未调节的）梯度：

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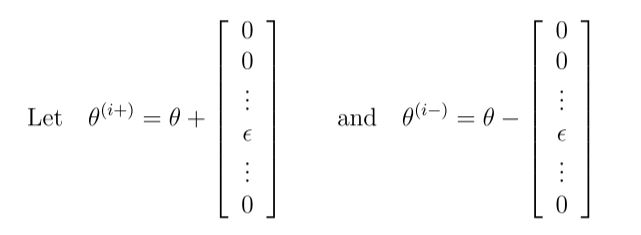
已生成极高可信度的说明](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAwADAAAD/4RDmRXhpZgAATU0AKgAAAAgABAE7AAIAAAAJAAAISodpAAQAAAABAAAIVJydAAEAAAASAAAQzOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEhhbiBXYW5nAAAABZADAAIAAAAUAAAQopAEAAIAAAAUAAAQtpKRAAIAAAADMzkAAJKSAAIAAAADMzkAAOocAAcAAAgMAAAIlgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Octave / MATLAB提示：只有在成功完成前馈和成本函数后，才能实施反向传播算法。 在实现反向传播算法时，如果遇到尺寸不匹配错误（Octave / MATLAB中的“不一致参数”错误），使用尺寸函数打印出正在使用的变量的大小通常是有用的。

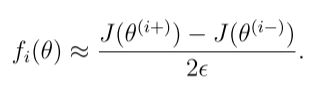
在实现了反向传播算法之后，脚本ex4.m将继续对您的实现运行梯度检查。 渐变检查将允许您增加您的代码正确计算渐变的信心。

2.4渐变检查

在你的神经网络中，你正在最小化成本函数J(Θ)。 对参数进行梯度检查，可以想象将参数Θ(1)，Θ(2) “展开”为一个长向量θ。 通过这样做，您可以将成本函数看作是J(θ)，并使用以下梯度检查程序。 假设你有一个函数fi(θ)据称计算J(θ)你想检查fi是否输出正确的微分值。



因此，θ（i +）与θ相同，除了它的第i个元素已经增加了。 类似地，θ（i-）是第i个元素减少的对应向量。 您现在可以通过检查每个i来验证fi（θ）的正确性：



这两个值应该相互接近的程度将取决于J的细节。但假设= 10-4，通常会发现上面的左侧和右侧将同意至少4 有效数字（通常还有更多）。

我们在computeNumericalGradient.m中实现了为您计算数值梯度的函数。 虽然您不需要修改该文件，但我们强烈建议您查看代码以了解其工作原理。

在ex4.m的下一步，它将运行提供的函数checkNNGradients.m，这将创建一个小的神经网络和数据集，将用于检查您的渐变。 如果您的反向传播实施是正确的，

你会看到一个小于1e-9的相对差异。

实用提示：在执行梯度检查时，使用输入单位和隐藏单位数量相对较小的小型神经网络效率更高，参数数量相对较少。 θ的每个维度需要对成本函数进行两次评估，这可能是昂贵的。 在函数checkNNGradients中，我们的代码创建了一个随机模型和数据集，与computeNumericalGradient一起用于梯度检查。 此外，在您确信您的梯度计算正确之后，您应该在运行学习算法之前关闭梯度检查。

实用提示：渐变检查适用于计算成本和渐变的任何功能。 具体而言，您可以使用相同的computeNumericalGradient.m函数来检查其他练习的梯度实现是否也是正确的（例如逻辑回归的成本函数）。

一旦你的成本函数通过（非规律化）神经网络成本函数的梯度检查，你应该提交神经网络梯度函数（反向传播）。

2.5正则化神经网络

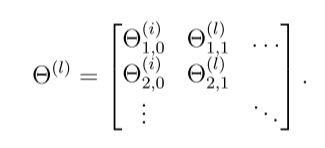
在成功实现反向传播算法之后，您将向渐变添加正则化。 为了说明正则化，事实证明，在使用反向传播计算梯度之后，可以将其作为附加术语添加。

具体来说，使用反向传播计算后，应该使用正则化

![图片包含 物体

已生成极高可信度的说明](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAwADAAAD/4RDmRXhpZgAATU0AKgAAAAgABAE7AAIAAAAJAAAISodpAAQAAAABAAAIVJydAAEAAAASAAAQzOocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEhhbiBXYW5nAAAABZADAAIAAAAUAAAQopAEAAIAAAAUAAAQtpKRAAIAAAADODQAAJKSAAIAAAADODQAAOocAAcAAAgMAAAIlgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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请注意，您不应该调整用于偏置项的Θ(l)的第一列。 此外，在参数Θ(l)ij中，i从1开始索引，并且j从0开始索引。因此，



有些令人困惑的是，Octave / MATLAB中的索引从1开始（对于i和j），因此Theta1（2,1）实际上对应于Θ(l)2,0（即，第二行第一列 矩阵Θ（1）如上所示）

现在修改计算nnCostFunction中的grad的代码来说明正则化。 完成后，ex4.m脚本将继续对您的实现运行梯度检查。 如果你的代码是正确的，你应该期望看到一个小于1e-9的相对差异。

你现在应该提交你的解决方案。

2.6使用fmincg学习参数

在成功实现神经网络代价函数和梯度计算后，ex4.m脚本的下一步将使用fmincg来学习一个好的设置参数。

训练结束后，ex4.m脚本将通过计算正确的示例百分比来报告分类器的训练准确性。 如果你的实现是正确的，你应该看到报告的训练准确率约为95.3％（由于随机初始化，这可能会变化大约1％）。 通过训练神经网络进行更多的迭代，可以获得更高的训练精度。 我们鼓励您尝试对神经网络进行更多的迭代训练（例如，将MaxIter设置为400），并改变正则化参数λ。 通过正确的学习设置，可以使神经网络完美地适应训练集。