本文采用了三种不同的深度学习方法.分别是MLP,CNN,LSTM.其中,CNN和LSTM并不是单独的简单模型,而是经过模型融合产生的新的模型,记作CNNs,LSTMs.

多层感知器(Multi-Layer Perceptron，MLP)也叫人工神经网络(Artificial Neural Network，ANN)，除了输入输出层，它中间可以有多个隐层。最简单的MLP需要有一层隐层，即输入层、隐层和输出层才能称为一个简单的神经网络。

卷积神经网络能够以高维向量的形式表现图像的内容。这些特征向量包含了丰富的视觉信息，对于事件图像的分类任务有着极强 的辅助作用。

LSTM作为处理序列数据的一种典型的深度学习方法，已被证明能够处理序列数据， 并应用于许多实际问题，如语音识别、图像字幕、音乐合成和行人轨迹预测。ＬＳＴＭ神经网络是一种时间递归神经网络，相比于以ＣＮＮ 为代表的的前馈网络，它可以处理与时间序列高度相关的问题，能够完成更为复 杂的分类任务。

本文的数据有两个组成部分.1个是solar panel power value. 另是一个是power value对应当前时刻的images.

ML, CNNs, LSTMs 都是对solar panel power value 做下一分钟power value预测.

MLP的输入数据只有solar panel power value, 先对solar panel power value做预处理,提取每一分钟power value的平均值, 并以此作为MLP神经网络的输入。经过两层的MLP网络训练,最后用sigmoid 函数进行回归, 从而得到对power value的预测结果。

CNNs 输入数据有solar panel power value 和对应的images. 首先,先对power value做预处理,提取每分钟power value的平均值, 并以此作为MLP神经网络的输入. 再对images做预处理,提取每分钟不同曝光程度的图片的feature. 并以此作为CNN神经网络的输入。用卷积神经网络从事件图像中提取的特征来构建特征序列，提取出images的feature再将MLP的输出和CNN的输出融合作为新的MLP的输入. 经过两层的MLP网络训练,最后用sigmoid 函数进行回归, 从而得到对power value的预测结果。

LSTMs 的输入数据和CNNs 一样.都是solar panel power value 和对应的images. 首先,先对power value做预处理,提取每分钟power value的平均值, 并以此作为MLP神经网络的输入. 再对images做预处理,提取每分钟不同曝光程度的图片的feature. 并以此作为CNN神经网络的输入。用卷积神经网络从事件图像中提取的特征来构建特征序列，再利用ＬＳＴＭ神经网络对输入具有记忆的特 性的特点，对序列输入进行融合，生成图像的表征。再将MLP的输出和LSTM的输出融合作为新的MLP的输入. 经过两层的MLP网络训练,最后用sigmoid 函数进行回归, 从而得到对power value的预测结果。

因为这个时间范围内,照片中可以捕捉到太阳的信息从而达到利用天空图像预测的目的

对于power value,该数据是每5秒采集一次.这篇论文的目标是通过历史的数据和图片来预测1分钟后的power value. 因为历史数据过于繁多,所以把历史数据简化为每分钟power value 的平均值.问题就转变为通过前几分钟的power value来预测下一分钟的power value.在处理power value过程中,delete photovoltaic power output around 0.

For image data, 单个CNN网络的输入对应的是一个个3×4通道的3维矩阵.(3 explosures in gray scale which only has one channel). The images are taken 1 minute before the current time t with interval 15s, which means 4 new images are used for 1 minute.

1.先找到每天开始拍摄图片的时间.把这些照片放入list时按文件创建的时间顺序.

2.根据获取到的每天开始拍摄图片的时间,对应的power value可以得到.

3. 选用8:00-16:00的照片和power value 信息. 因为每日照片是从早晨8:00左右开始生成, 16:00之后照片中阳光的信息比较少.

4.将每日的power values 和照片信息都存入list.照片在放入list中先resize成size of 128\*128, 再转成1维灰色图片.每15秒选取当前时刻level 2,3,4曝光度的图片.再将一分钟的12张图片进行通道融合,生成一个新的图片. 每个image set 中 有5分钟的照片信息.

3. This project uses 5 min data to predict next 1 min power value. Therefore, one set of power values has 6 min data. First 5 min values are the input of MLP. The last is the ground truth of the network.

本文采用的数据

For MLP part, the network adds dropout layer to prevent overfitting.

For CNNs and LSTMs, in the training phase, 5 new images which have already been preprocessed is input into the network model. Echo training is used. According to the actual training speed.

In the parameter setting stage, in order to facilitate the comparison of experimental results, the learning rate was set to 0.001. The training process updates the network parameters according to the Adam so that the model reaches the optimal solution. The learning decay rate is 0.001/120.

The experiments use the output of the sigmoid activation function to predict the future 1-min power value.

In the experiments, each model is trained separately with 120 epochs of training.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | clear | | Cloudy | | overcast | | all | |
|  | mae | rmse | mae | rmse | mae | rmse | mae | rmse |
| Mlp | 18.33 | 32.19 | 97.41 | 180.32 | 44.23 | 88.44 | 68.12 | 133.32 |
| Cnns | 17.76 | 30.37 | 90.10 | 169.21 | 37.31 | 76.78 | 64.55 | 121.23 |
| lstms | 15.63 | 28.14 | 87.31 | 160.39 | 35.33 | 69.12 | 62.71 | 119.89 |

The prediction of photovoltaic power values can reduce the impact of these unfavorable factors on the grid, which is beneficial to provide important suppo t for power gr id scheduling, decision-making and effective reduction for the operating cost of power system. However, estimating PV based on the relative position of sun and cloud, however, is quite challenging because of the changing weather patterns.

Therefore, this paper proposed three different neural network models(MLP,CNNs,LSTMs) to solve this problem. The specific work content of the thesis is as follows.

1.本文阐述了光伏发电的优势和意义.对现有的预测光伏发电的方法展开了论述,指出的方法的优点和缺陷.

2.本文介绍了采用的数据来源以及数据生成的形式.同时还论述了本文准备采取的3种不同的neural networks.并分析了三种网络特点和优点.

3.本文具体介绍了了power values 和sky images预处理的步骤和方式.同时阐述了本文采用的三种不同神经网络的模型结构.此后还较少了神经网络采用的loss function.

4根据不同的天气.将预处理后的数据分为三部分,并将数据作为神经网络的输入对网络进行训练.实验结果表明LSTMs的误差最小,效果相对来说是三种模型中表现最好的.

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which is beneficial to provide important support for power grid scheduling, decision-making and effective reduction for the operating cost of power system. However, estimating PV based on the relative position of sun and cloud, however, is quite challenging because of the changing weather patterns.

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1.This article explains the advantages and significance of photovoltaic power generation. It discusses the existing methods of predicting photovoltaic power generation and points out the advantages and disadvantages of the method.

2. The data source and the form of data generation are well explained. It also discusses 3 different neural networks that this article intends to adopt. The characteristics and advantages of three types of networks are also analyzed.

3. The steps and methods of preprocessing power values ​​and sky images are specifically introduced .

At the same time, the model structure of three different neural networks used in this paper is explained.

Then the loss function used by neural networks has been introduced.

4 According to different weather, the preprocessed data is divided into three parts, which uses the data as the input of the neural network to train the network. The experimental results show that the error of LSTMs is the smallest, and the effect is relatively best among the three models.

这项工作的局限之一是数据仅仅为1个月的数据,该短时间天气变化情况并不丰富,没有涵盖一些极端天气.相对而言泛化能力不是很强. 而且获取数据的站点单一,采样的数据并不丰富.

网络训练采用的是单通道的灰度图,会损失一部分feature,从而使模型在提取图像特征方面不够精确.

在cnn网络结构中,采用的为ＶＧＧｌ６－Ｎｅｔ，实验结果表明深层次的网络结构的分类效果更好，因此可以考虑使用其他更深的深度网络结构模型。

首先,将数据集扩充,采集更为丰富的天气情况sky的images和对应的power value作为数据集.

其次,在获取图像信息时,可以利用attention 方法,可以更好的获取图片特征, **并且通过将任务分解，设计不同的网络结构（或分支）专注于不同的子任务，重新分配网络的学习能力，从而降低原始任务的难度，使网络更加容易训练。**

**本文采用Cnn结构是vgg16,可以将vgg16结构换成ResNet,对网络进行训练测试预测效果.**

The prediction of photovoltaic values is beneficial to provide important support for power grid.

预测短期光伏值可以有效的节约能源,高效的管理电网.本文的数据分为两个部分,一部分是来源于光伏面板的光伏值.另一部分来源于光伏面板旁边的相机捕捉到的太阳周边的图像.本文利用神经网络寻找天空图像和光伏值之间的关系.本文基于三种神经网络结构,MLP,CNN,LSTM将其结合,设计了三种不同神经网络的结构.MLP,CNNs,LSTMs.实验中先分别对光伏值和图片进行了预处理,使其能成为神经网络的输入数据.再将这些数据作为输入训练网络.实验表明,在1分钟光伏值预测中,MLP模型比持久性模型rmse得分高10%. CNNs模型结合了图像特征,表现更好,得分高了11%.LSTMs的得分是最高为15%.相比CNNs网络多考虑了时间特性,从而胜过其他方法.