

UNIVERSITY NAME (IN BLOCK CAPITALS)

# Weather Classification

by

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degree of Master

in the  
Chunhua Shen  
School of Computer Science

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# Declaration of Authorship

I, Junjie Zhang, declare that this thesis titled, ‘Weather Classification’ and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

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## *Abstract*

Scene classification is an important field in computer vision. For similar weather condition, there are some obstacles for extracting features from outdoor images. In this paper, we present a novel approach to classify cloudy and sunny weather. Inspired by recent study of deep multi-layer neural network and spatial pyramid pooling, generate a model based on imagenet dataset. Starting with parameters trained from more than 1 million images, we fine-tune the parameters. Experiment demonstrates that our classifier can achieve the state of the art accuracy.

# *Acknowledgements*

The acknowledgements and the people to thank go here, don't forget to include your project advisor...

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# Abbreviations

**LAH** List Abbreviations **Here**



# Physical Constants

Speed of Light  $c = 2.997\,924\,58 \times 10^8 \text{ ms}^{-\text{s}}$  (exact)

# Symbols

$a$	distance	m
$P$	power	W ( $\text{Js}^{-1}$ )
$\omega$	angular frequency	$\text{rads}^{-1}$

*For/Dedicated to/To my...*

# Chapter 1

## Introduction

### 1.1 Overview

Computer is one of the most significant inventions in history. It provides huge power in data processing field, like scientific computation. Also, computer system can aid human being in daily life, for example driverless vehicles. However, human brain still has compelling advantage in some fields, like identifying our keys in our pocket by feel. The complex processes of taking in raw data and taking action based on the pattern are regarded as pattern recognition. Pattern recognition has been important for people daily life for a long period and human brain has developed an advanced neural and cognitive system for such tasks.

Weather classification is one of the most important pattern recognition tasks which relates our work and lives. There are several major kinds of weather conditions, like sunny, cloudy, rainy. And people can classify them easily through eyes. However, it is not a easy job for machines, especially in computer vision literacy.

In this thesis, I describe an approach to this problem of weather classification based upon the new big trend in machine learning, and more precisely, deep learning. It differs with feature detectors method that extracts features manually and training a model to do classification.

Compared to shallow learning which includes decision trees, SVM and naive bayes, deep learning passes input data through several non-linearities functions to generate features and does classification based on the features. It generates a mapping and finds a optimum solution.

## 1.2 Statistical Pattern Recognition

In the statistical approach, the pattern is represented in terms of  $d$  dimensional feature vector and each element of the vector describes some subjects of the example. In brief, three components are essential to do statistical pattern recognition. First is a representation of the model. Second is an objective function used to evaluating the accuracy of the model. Third is an optimization method for learning a model with minimum errors.

## 1.3 Artificial Neural Networks

Artificial neural networks(ANNs) were proposed in the mid-20th century. The term is inspired by the structure of neural networks in the brain. It is one of the most successful statistical learning models used to approximate functions. Learning with ANNs yields an effective learning paradigm and has achieved cutting-edge performance in computer vision.

The single-layer perceptron has shown great success for a simple model. For increasing complex models and applications, multi-layer perceptron has exhibited the power of features learning. With hardware developing At the same time, the demanding of more efficient optimizing and model evolution methods is needed for BIG DATA.

Recent development in ANNs approaches have giantly advanced the performance of state-of-the-art visual recognition systems. With implementing deep convolutional neural networks, it achieves top accuracy in ImageNet Challenge. The model has been used in related fields and succeeds in competition.

## 1.4 Weather Classification

Weather classification is an important job in daily life. In this thesis, we are focused on two class weather conditions, sunny and cloudy.

There are some obstacles in front of weather classification. First, because inputting pixels are independent and high dimension, say a 500x500 RPG image means 750000 pixels, computation is huge. Second, some simple middle level image characters are difficult to machines, like light, shading, sun shine. It is still not easy to detect these characters with high accuracy. Thirdly, there are no decisive features, for example brightness and

lightness, to classify scene. For example, sun shine can be both found in sunny and cloudy weather. Last but not least, outdoor images are various background.

## Chapter 2

# Introduction

### 2.1 Single-Layer Networks

Artificial neurons were introduced as information processing devices more than fifty years ago[? ]. Following the early work, perceptrons were deployed in layers to do pattern recognition job. A lot of resource was invested in researching capability of learning perceptrons theoretically and experimentally. As shown in Figure 2.1, a perceptron computes a weighted summation of its  $n$  inputs and then thresholds the result to give a binary output  $y$ . We can treat  $n$  input as an vector with  $n$  elements, and represent the vector as either class A(for output +1) or class B(for output -1).

Each output is updated according to the equation:

$$y_i = f(h_i) = f\left(\sum_j w_{ij}x_j\right) \quad (2.1)$$

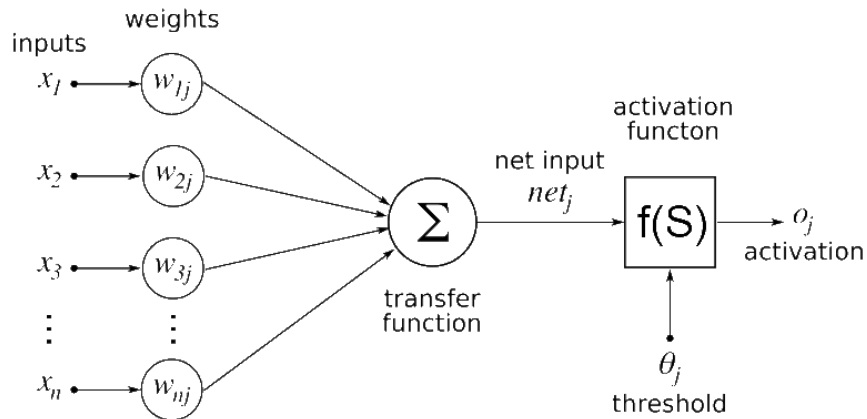


FIGURE 2.1: Diagram of a perceptron.

where  $y_i$  is the  $i$ th output,  $h_i$  is the net input into node  $i$ , The weight  $w_{ij}$  connects the  $i$ th output and the  $j$ th input, and  $x_j$  is the  $j$ th input. The function  $f(h)$  is the activation function and usually makes up the form

$$f(h) = \text{sign}(h) = \begin{cases} -1 & h < 0 \\ 1 & h \geq 0 \end{cases} \quad (2.2)$$

We can also represent 2.2 in vector notation, as in

$$y = f(h) = f(\mathbf{w} \cdot \mathbf{x}) \quad (2.3)$$

where  $\mathbf{w}$  and  $\mathbf{x}$  can be regarded as  $n \times 1$  dimensional column vectors, and  $n$  is the number of input data. The term  $w \cdot x$  in 2.3 constructs a  $(n - 1)$ -dimension hyperplane which passes the origin. The hyperplane can be shifted by adding an parameter to 2.1, for example

$$y = f(h) = f(\mathbf{w} \cdot \mathbf{x} + \mathbf{b}) \quad (2.4)$$

We can have the same effect by putting a constant value 1 and increase the size of  $x$  and  $w$  by one. The extra weight  $w$  with fixed value 1 is called *bias weight*; it is adaptive like other weights and provides flexibility to hyperplane. Then we get:

$$y = f(h) = f\left(\sum_{i=0}^n w_i x_i\right) \quad (2.5)$$

The aim of learning is to find a set of weights  $w_i$  so that:

$$\begin{aligned} y = f\left(\sum_{i=0}^n w_i x_i\right) &= 1 & x \in \text{ClassA} \\ y = f\left(\sum_{i=0}^n w_i x_i\right) &= 0 & x \in \text{ClassB} \end{aligned}$$

## 2.2 Multi-Layer Networks

Single-layer networks have some important limitation in terms of the representing range of functions. We are seeking to learn the nonlinearity as the linear discriminant. To improve the representation capability, we can stack layers networks. This is the approach of multilayer neural networks. Multilayer neural networks implement linear discriminants via mapping input data to a nonlinear space. They can use fairly simple algorithms to learn form of the nonlinearity from training data.



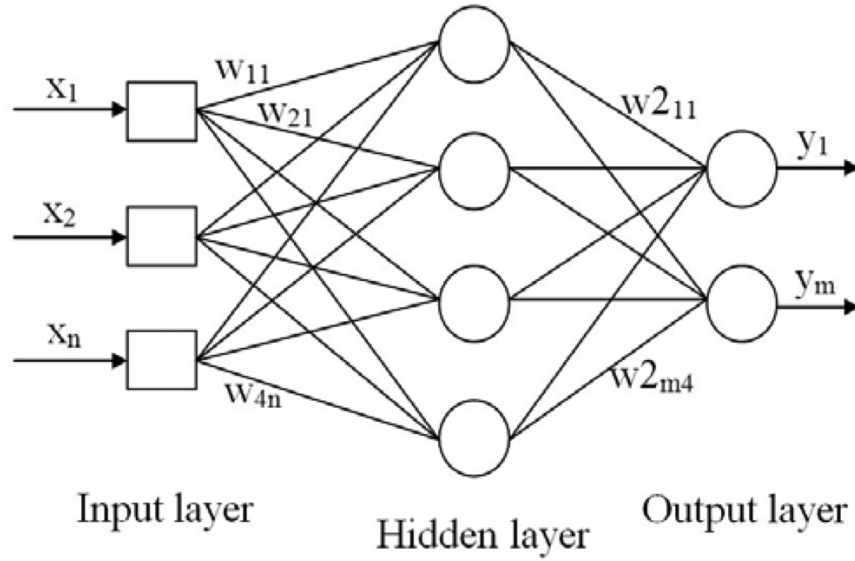


FIGURE 2.2: Diagram of a feedford neural networks.

In the thesis, we limit multi-layer networks in subset of feedforward networks. As feed-forward networks can provide a general mechanism for representing nonlinear functional mapping between a set of input data and a set of labels. The 2.2 is a feedforward network having two layers of adaptive weights. In the example, the middle column perceptrons act as hidden units. The network has  $n$  inputs, 4 hidden units and  $m$  output units. The network diagram represents the function in the form

$$y_m = f\left(\sum_{j=0}^m w_{j4}^{(2)} f\left(\sum_{i=0}^n w_{4i}^{(1)} x_i\right)\right) \quad (2.6)$$

Because networks have differentiable activation functions, backpropagation can be applied to find the derivatives of an error function related to the weights and biases in the network.

## 2.3 Artificial Neural Networks

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## Appendix A

# Appendix Title Here

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