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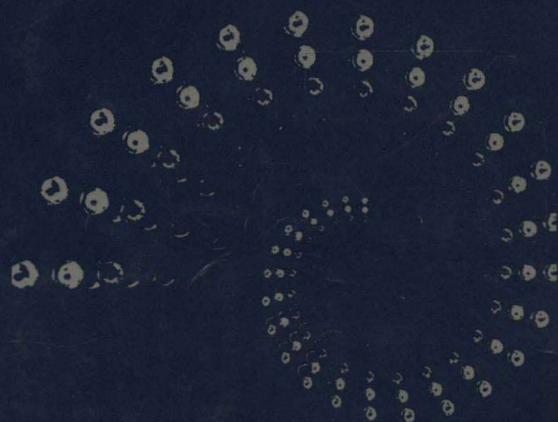
缩编国外精品教材

Introduction to Digital Image Processing with MATLAB

数字图像处理概论

[美] Alasdair McAndrew 著

胡小平 缩编



THOMSON



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数字图像处理概论

Introduction to Digital Image Processing with MATLAB

本书是美国Alasdair McAndrew 所著Introduction to Digital Image Processing with MATLAB一书的缩编版。按照我国60学时的教学要求缩编而成。

缩编后的内容充实，涵盖了低层次图像处理（图像增强、图像恢复）和高层次图像处理（形态学、图像分割、图像表示与描述和图像压缩）的全部基础内容，习题和教材内容结合紧密，便于学生巩固所学知识。同时，缩编作者对原书部分难点进行了注释，帮助读者更好地理解所学内容。

本书可作为图像处理专业课程本科生双语教学教材。

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英文缩编版

[美]

Alasdair McAndrew

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Alasdair McAndrew

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缩编说明

数字图像处理是信息技术中的一门新兴学科,它所涵盖的内容极其丰富。目前全国高校的双语教学逐步推广开来,但与之相适应的教材却不多,部分学校直接选用了国外原版教材,但其中还是存在不少问题。广大师生迫切需要一本适合我国教学实际情况的教材,因此如何从种类繁多的国外教材中挑选出适合我国大学本科教学内容的教材并进行精简就显得特别重要。根据国内大学本课程本科教学的学时数一般在 60 学时左右的特点,我们从国外众多的教材中经过仔细筛选确定了本教材。

在教材的筛选过程中,我们基于以下几点原则进行操作:

首先是读者群体要明确。目前我国市场上流行的许多教材面向的读者既可以是高年级本科生也可以是研究生,因而内容较多,但是许多内容因受学时数限制而不能讲授,造成部分资源浪费。本教材只面向高年级本科生,因而篇幅恰到好处,成本低,不会造成浪费。

其次是读者群体为初次接触图像处理学科的学生,因而在内容的叙述上要直观且实例丰富便于自学。目前我国图像处理学科的教材所面向的读者群体不唯一,其特点是理论叙述较多而如何实施这些理论的实例却叙述较少或没有,造成学生自学非常困难。

再者与职业学校的学生不一样,对高年级本科生来说,教材必须包含适当的图像处理理论,但不能有过多的数学推导,以免将图像处理教材数学化。

最后因图像处理是借助于计算机进行的,在教学时必须辅助于一定的软件编程工具将理论算法编成程序,对一些典型的图片进行处理以验证算法的有效性。MATLAB 语言是一种功能强大的工程计算语言,因它是基于矩阵的数据格式所以特别适合图像处理。MATLAB 还有专门的图像处理工具箱,为读者进一步研究图像处理的算法提供了方便,因而我们选择了基于 MATLAB 编程的图像处理工具。

教材选定后我们按 60 学时的教学要求对原书进行了缩编,缩编后全书共 14 章。本缩编版教材与其他教材相比具有以下特色:

文字叙述精简,重点突出,注重以图示和程序示例的方式进行阐述,因而不会给人留下一看满篇文字就烦得不愿看下去的感觉。这种特点尤其适合我国学生,目前他们的外语应用能力一般不太强,阅读耐心较差,这直接影响到阅读理解力。本书将帮助他们克服这些困难。

理论联系实际密切,示例典型具有启发性,给教师教学带来极大方便。作者在阐述相关理论知识后立即给出多个示例说明如何运用该理论知识,让人感到每学完一个内容后不空洞,心里踏实。可以看出本书中的所有示例程序和图示都是作者自己亲自编写的,而非介绍他人的思想,因而叙述清楚,容易理解。

写作风格独特。目前大多数书由多个作者合著而成,每个作者按章节分工进行撰写,因作者风格各不相同,章节之间的衔接一般会出现不平滑的情况。本教材由一位作者独著完成,思路清

晰,叙述深入浅出,以自学教程方式撰写,容易跟踪,不易走神。在很多场合,作者将程序分步执行,详细解释结果,因此很能抓住读者的心。此外,作者在适当部位特别指出了初学者在使用 MATLAB 软件进行图像处理时容易犯的错误。

全书内容充实,涵盖了低层次图像处理(图像增强、图像恢复)和高层次图像处理(形态学、图像分割、图像表示与描述和图像压缩)的全部基础内容。

与全文翻译的教材不一样,本教材只对部分难点进行注释,因而避免了翻译出错和改变了作者原始风格的问题。

习题和教材内容结合紧密,便于巩固所学知识。

综上所述,我们认为该教材无论在专业内容还是在文字叙述的难易程度上都非常适合我国本科学生的理解水平,是一本值得推荐的好书。

推荐的授课学时:

章节	1	2	3	4	5	6	7	8	9	10	11	12	13	14
学时	2	2	4	4	4	4	6	6	6	4	6	4	4	4

由于缩编者的学识水平及时间的限制,在缩编过程中不免有欠缺和错误,敬请同行专家们批评指正。

胡小平

2007 年 3 月

PREFACE

Human beings are predominantly visual creatures, and our computing environments reflect this. We have the World Wide Web, filled with images of every possible type and provenance, and our own computers are crammed with images from the operating system, downloaded from elsewhere, or taken with our digital cameras. Then there are the vast applications that use digital images: remote sensing and satellite imaging, astronomy, medical imaging, microscopy, industrial inspection. . . .

This book is an introduction to **digital image processing**, from a strictly elementary perspective. We have selected only those topics that can be introduced with simple mathematics; however, these topics provide a very broad introduction to the discipline.

This book is based on some very successful image-processing subjects that have been taught for the past few years at Victoria University in Melbourne, Australia. The topics chosen, and their method of presentation, are the result of many hours of talking to and learning from the hundreds of students who have taken these subjects.

There are a great many books on the subject of image processing, and this book differs from all of them in several important respects:

Not too much mathematics. Some mathematics is necessary for the explanation and discussion of image-processing algorithms. But this book attempts to keep the mathematics at a level commensurate with elementary undergraduate computer science.

The level of mathematics required is about one year's study at a tertiary level, including calculus and linear algebra.

A discrete approach. Since digital images are discrete entities, we have adopted an approach using mainly discrete mathematics. Although calculus is required for the development of some image-processing topics, we attempt to connect the calculus-based (continuous) theory with its discrete implementation.

A strong connection between theory and practice. Since we have used a mainly discrete approach to explain the material, it becomes much easier to extend the theory into practice. This becomes particularly significant when we develop our own MATLAB functions for implementing specific image-processing algorithms.

Software based. There are image-processing books that are based on programming languages, generally C or Java. The problem is that to use such software, a specialized image-processing

library must be used, and, at least for C, there is no standard for this. A problem with the Java image-processing libraries is that they are not really suitable for beginning students.

This book is based entirely on MATLAB and its Image Processing Toolbox. This provides a complete environment for image processing that is easy to-use, easy to explain, and easy to extend.

Plenty of examples. *All* the example images in this text are accompanied by MATLAB commands. Thus, if you work carefully through the book, you can create the images as given in the text.

Exercises. Chapters finish with a selection of exercises that enable the student to consolidate and extend the material. Some of the exercises are pencil-and-paper, designed for better understanding of the material, and others are MATLAB based to explore the algorithms and methods of that chapter.

A Note on the Images

Some of the images used in this book are the author's and may be used freely and without restriction. They are:

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CHAPTER 1

Introduction

1.1 Images and Pictures

As we mentioned in the preface, human beings are predominantly visual creatures: we rely heavily on our vision to make sense of the world around us. We not only look at things to identify and classify them, but we can scan for differences and obtain an overall rough feeling for a scene with a quick glance.

Humans have evolved very precise visual skills: we can identify a face in an instant, we can differentiate colors, and we can process a large amount of visual information very quickly.

However, the world is in constant motion. Stare at something for long enough and it will change in some way. Even a large solid *object*, like a building or a mountain, will change its appearance depending on the time of day (day or night), amount of sunlight (clear or cloudy), or various shadows falling upon it.

We are concerned with single images, snapshots, if you like, of a visual scene. Although image processing can deal with changing scenes, we will not discuss it in any detail in this text.

For our purposes, an **image** is a single picture that represents something. It may be a picture of a person, or animals, or an outdoor scene, or a microphotograph of an electronic component, or the result of medical imaging. Even if the picture is not immediately recognizable, it will not be just a random blur.

1.2 What is Image Processing?

Image processing involves changing the nature of an image in order to either

1. improve its pictorial information for human interpretation, or
2. render it more suitable for autonomous machine perception.

We shall be concerned with **digital image processing**, which involves using a computer to change



Figure 1.1 Image sharpening.

(a) The original image. (b) Result after sharpening.

the nature of a **digital image** (see above). It is necessary to understand that these two aspects represent two separate but equally important aspects of image processing. A procedure that satisfies condition 1 — a procedure that makes an image look better — may be the very worst procedure for satisfying condition 2. Humans like their images to be sharp, clear, and detailed; machines prefer their images to be simple and uncluttered.

Examples of condition 1 may include

- enhancing the edges of an image to make it appear sharper. An example is shown in Figure 1.1. Note how the second image appears cleaner; it is a more pleasant image. Sharpening edges is a vital component of printing. For an image to appear at its best on the printed page, some sharpening is usually performed.
- removing noise from an image, noise being random errors in the image. An example is given in Figure 1.2. Noise is a very common problem in data transmission; all sorts of electronic components may affect data passing through them, and the results may be undesirable. As we shall see in Chapter 8, noise may take many different forms, each type of noise requiring a different method of removal.
- removing motion blur from an image. An example is given in Figure 1.3. Note that in the deblurred image Figure 1.3(b) it is easier to read the number plate and to see the spikes on the fence behind the car, as well as other details not at all clear in the original image Figure 1.3(a). Motion blur may occur when the shutter speed of the camera is too long for the speed of the object. In photographs of fast-moving objects, athletes or vehicles, for example, the problem of blur may be considerable.

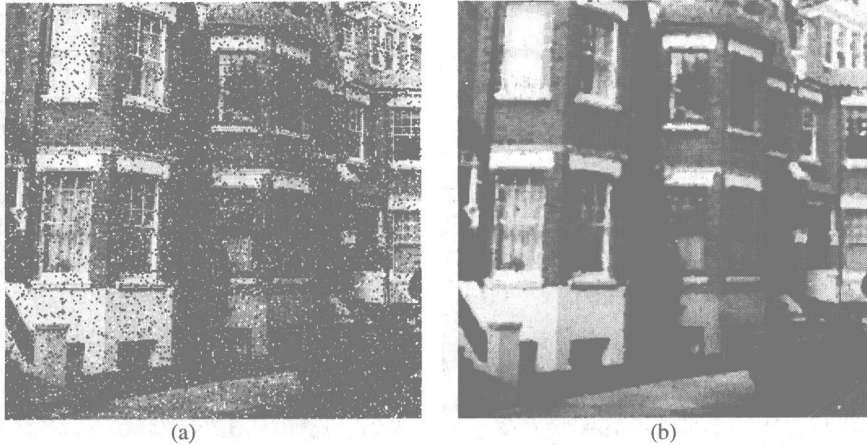


Figure 1.2 Removing noise from an image.
(a) The original image. (b) After removing noise.

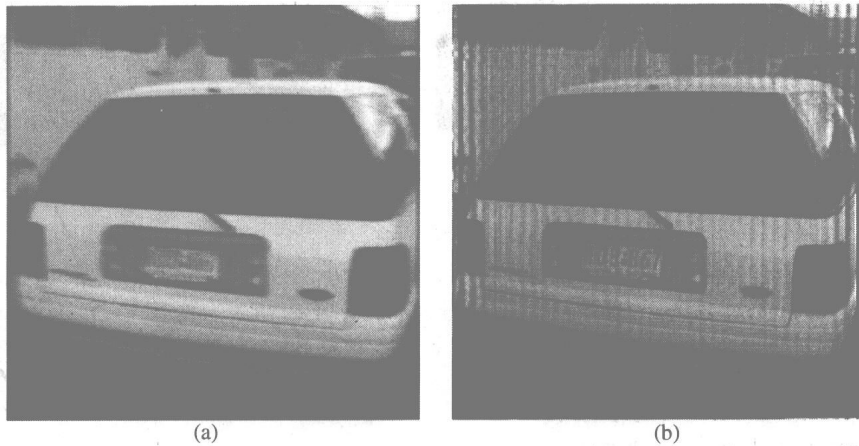


Figure 1.3 Image deblurring.
(a) The original image. (b) After removing the blur.

Examples of condition 2 may include

- obtaining the edges of an image. This may be necessary for the measurement of objects in an image. An example is shown in Figure 1.4 (a and b). Once we have the edges we can measure their spread and the area contained within them. We can also use edge-detection algorithms as a first step in edge enhancement, as we saw above. From the edge result, we see that it may be necessary to enhance the original image slightly, to make the edges clearer.
- removing detail from an image. For measurement or counting purposes, we may not be interested in all the detail in an image. For example, when a machine inspects items on an assembly line, the only matters of interest may be shape, size, or color. For such cases, we might want to simplify the image. Figure 1.5 shows an example; in image Figure 1.5(a) there is a picture of an African buffalo, whereas image Figure 1.5(b) shows a blurred version in which extraneous detail (such as the logs of wood in the background) have been removed. Notice that in image Figure 1.5(b) all the fine detail is gone; what remains is the coarse structure of the image. We could, for example, measure the size and shape of the animal without being distracted by unnecessary detail.

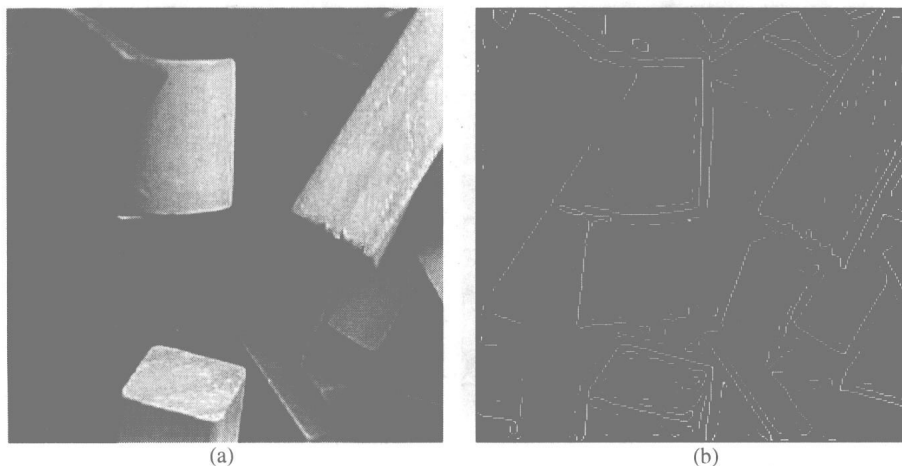


Figure 1.4 Finding edges in an image.
(a) The original image. (b) Its edge image.

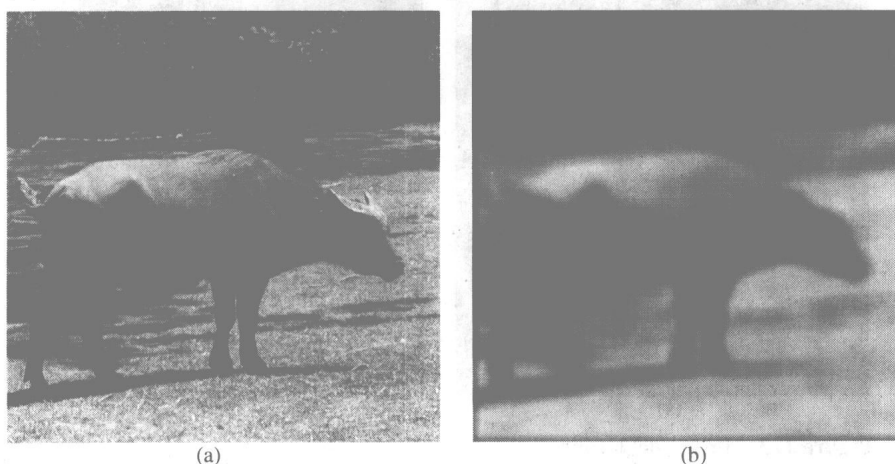


Figure 1.5 Blurring an image.
(a) The original image. (b) Blurring to remove detail.

1.3 Image Acquisition and Sampling

Sampling refers to the process of digitizing a continuous function. For example, suppose we take the function

$$y = \sin(x) + \frac{1}{3}\sin(3x)$$

and sample it at 10 evenly spaced values of x only. The resulting sample points are shown in Figure 1.6. This shows an example of **undersampling**, where the number of points is not sufficient to reconstruct the function. Suppose we sample the function at 100 points, as shown in Figure 1.7. We now can clearly reconstruct the function; all its properties can be determined from this sampling. To