plications of machine learning which are designed to solve very specific and focused problems, and while these are extremely useful they fall far short of the tremendous breadth of capabilities of the human brain. This has led to the introduction of the term *artificial general intelligence*, or AGI, to describe the aspiration of building machines with this much greater flexibility. After many decades of steady progress, machine learning has now entered a phase of very rapid development. Recently, massive deep learning systems called large language models have started to exhibit remarkable capabilities that have been described as the first indications of artificial general intelligence (Bubeck *et al.*, 2023).

Chapter 12

1.1. The Impact of Deep Learning

We begin our discussion of machine learning by considering four examples drawn from diverse fields to illustrate the huge breadth of applicability of this technology and to introduce some basic concepts and terminology. What is particularly remarkable about these and many other examples is that they have all been addressed using variants of the same fundamental framework of deep learning. This is in sharp contrast to conventional approaches in which different applications are tackled using widely differing and specialist techniques. It should be emphasized that the examples we have chosen represent only a tiny fraction of the breadth of applicability for deep neural networks and that almost every domain where computation has a role is amenable to the transformational impact of deep learning.

1.1.1 Medical diagnosis

Consider first the application of machine learning to the problem of diagnosing skin cancer. Melanoma is the most dangerous kind of skin cancer but is curable if detected early. Figure 1.1 shows example images of skin lesions, with malignant melanomas on the top row and benign nevi on the bottom row. Distinguishing between these two classes of image is clearly very challenging, and it would be virtually impossible to write an algorithm by hand that could successfully classify such images with any reasonable level of accuracy.

This problem has been successfully addressed using deep learning (Esteva *et al.*, 2017). The solution was created using a large set of lesion images, known as

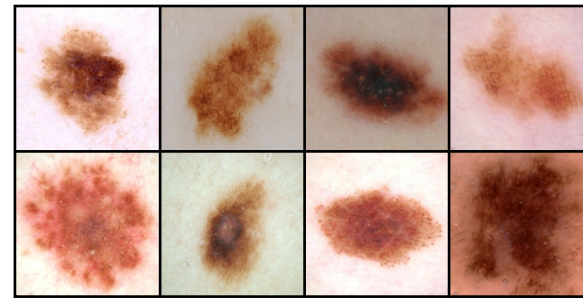

Figure 1.1 Examples of skin lesions corresponding to dangerous malignant melanomas on the top row and benign nevi on the bottom row. It is difficult for the untrained eye to distinguish between these two classes.