II.2.1 Basic Aims and Requirements

Diagnosis of melanocytic skin tumours is traditionally based on the subject of evaluation of images by an expert in the discipline. Despite increasing refinement of subjective criteria – introducing some degree of “objectivity” – there is a continuous demand for truly objective diagnostic features. This means features independent of the subjective judgement of a human observer, or, more drastically, features created and interpreted by a machine.

The essential prerequisite for any approach for an automatic melanocytic lesion diagnosis is a set of digital data which can be used for automated analysis. In most approaches, this data set represents a digitized image which may have been acquired by any number of methods, ranging from clinical photography to three-dimensional reconstruction of confocal laser scanning microscopic images. The entire undertaking may serve two different goals: On the one hand, digital data processing may be used to enhance visually recognizable criteria – which finally are still evaluated by a human observer. On the other hand, digital data processing should directly result in a diagnostic suggestion generated by the machine independently of the human observer. The latter approach is the more fascinating one, although it has not yet revealed its full potential.

II.2.2 Clinical Images

Some efforts have been made to use clinical images for automatic diagnosis. Usually colour is taken as the main source of data, although colour itself is hardly a reliable parameter. Usually, some kind of distribution (or texture) analysis has to be considered. Chen et al., for example, showed that not the presence of melanoma-specific colour pixels per se, but colour clustering is the more reliable feature [3]. A preliminary report by Manousaki and coworkers [15] deals with subtle colour features: Intensity values of each of the three colour channels were plotted as the third dimension of the plane clinical photograph, and the surface of the plot was analysed by methods of fractal mathematics including fractal dimensionality and lacunarity. A major problem is often the identification of relevant features. Chang and colleagues therefore proposed a systematic heuristic approach to feature selection particularly applicable to clinical images [2].

Clinical images of individual lesions are usually inferior to dermoscopic images with respect to automated classification [22]. Clinical imag-
es, however, are gaining some importance as whole-body screening tools. The detection and demarcation of pigmented lesions alone is a sophisticated task [9] which is an essential prerequisite for any subsequent detailed analysis and automatic diagnosis.

II.2.3 Digital Dermoscopy

At present, dermoscopic digital images seem to be the most promising source for automatic melanoma diagnosis. This may be due in part to the fact that standardization is more easily achieved than in clinical imaging, and due in part to the higher magnification and pixel resolution. The potential target structures are manifold: Stoecker and coworkers identified asymmetric structureless areas (“blotches”) [28], whereas Seidenari et al. based their classification algorithm on average colour values within square pixel blocks [25]. Following the method of a preliminary study by Kahofer et al. [13], Gerger and coworkers used tissue counter analysis [27] to diagnose melanoma in dermoscopy images [6]. Rubegni et al. [23] and Oka et al. [18] developed advanced diagnostic systems based on dermoscopic images, one as a built-in-module of a digital dermoscopy device, and the other as a classification program accessible via the Internet.

Particular emphasis has been put on the possibility of sequential dermoscopic images. Visual analysis of consecutive images taken a few months apart has been shown to increase the proportion of true melanomas within the set of lesions which were finally excised [10], and facilitated the detection of melanomas which did not display the usual diagnostic features (so-called featureless melanomas) [14]. Automatic comparison of sequential images would be a valuable undertaking in the future.

II.2.4 Other Methods

There are a growing number of imaging methods for melanocytic lesions. Although most of them have not yet been proven to be reliable for automatic diagnostic procedures, there are promising preliminary results.

II.2.4.1 Spectral Analysis

Spectral analysis is a method beyond simple three-channel colour analysis. Spectral analysis creates a three-dimensional data cube of two-dimensional images, with each plane of the cube representing a particular wavelength [4]. Depending on the attempted wavelength resolution, up to several hundred two-dimensional images would be possible. Usually, however, analysis is limited to a small number of wavelengths which had turned out to be of discriminatory power. In 2001, Farkas and Becker reported automatic detection of the melanoma component in a complex melanocytic skin lesion based on spectral analysis. Pseudo-colour images clearly denoted the malignant portion of the lesion [4]. Spectral intracutaneous analysis (SIA) is based on eight narrow-width wavelength images between 400 and 1000 nm and facilitates the demonstration of melanin, haemoglobin and collagen within skin lesions [16]. Melanomas usually present peculiar patterns which might be suitable for automatic diagnosis. Murphy et al. [17] applied fibre-optic diffuse reflectance spectroscopy to melanocytic skin lesions and found a remarkably high degree of diagnostic accuracy. Another highly sophisticated approach is Raman spectroscopy. This type of laser-induced spectral analysis is based on molecular vibrations and therefore represents to some degree the chemical composition of a lesion. Gniadecka et al. [7] applied this method to freshly excised tissue specimens obtained by punch biopsy and achieved a diagnostic accuracy comparable to automatic dermoscopy analysis.

II.2.4.2 In-Vivo Confocal Laser Scanning Microscopy

In-vivo confocal laser scanning microscopy facilitates non-invasive examination of superficial skin layers at the cellular level [5]. Qualitative and semiquantitative diagnosis of melanoma is largely based on the architectural arrangement of keratinocytes in the spinous layer and on the size, shape and distribution of pigmented cells [5]. Digital image processing has been used to