SIAscopy assists in the diagnosis of melanoma by utilizing computer vision techniques to visualise the internal structure of the skin

Marc Moncrieff[1*], Symon Cotton[2], Per Hall[1], R. Schiffner[4], U.Lepski[4], Ela Claridge[3]
[1] Addenbrooke' Hospital, Cambridge, UK; [2] Astron Clinica, UK; [3] University of Birmingham, UK. Department of Dermatology, [4]University of Regensburg, Germany

Abstract: A technique for structurally decomposing skin is presented in the form of SIAscopy. Its use in removing some of the subjective decisions required to diagnose melanoma at an early stage is discussed. An increase in the diagnostic accuracy for melanoma diagnosis is shown.

1. Introduction

Melanoma is a potentially fatal disease. Each year:

- Tens of millions of worried patients present at primary care.
- There are 130,000 cases of melanoma worldwide [1].
- There are 37,000 deaths worldwide [1].
- The mortality rate is increasing by 6.4% in US [2]

The well-publicised risks of sun exposure and skin cancer in Europe and North America [3] result in an estimated tens of millions of patients visiting general practitioners each year.

Skin cancer can be cured with minor surgery costing a few hundred pounds if the disease is detected early enough. The probability that a malignant lesion is identified in the primary care setting is less than 50% [4] because the diagnosis is difficult and the prevalence of the cancer can be in the order of 1 case in 500 patients presenting themselves for diagnosis. However the fact that 27% of patients who contract the disease die, reflects on the current diagnostic effectiveness [5].

When the primary care doctor becomes suspicious and refers a patient to the hospital or clinic, on average between 2 and 50 benign lesions are removed in the process of detecting each new case of melanoma [6]. Exact numbers depend on the financial structure of the health care system involved.

2. Image acquisition with a SIAscope

The SIAscope (SIA = Spectrophotometric Intracutaneous Analysis) is a device developed by our research group [7-8] and Astron Clinica.

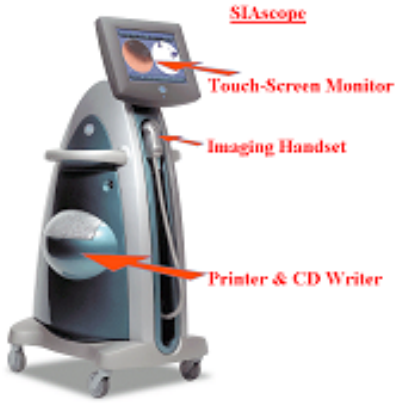


Figure 1: SIAscope

* Corresponding author: marc.moncrieff@cwcom.net

SIAscopy is a method of probing the skin with both visible and infrared light to return information regarding the composition, concentration and position of various chromophores within a horizontal plane. In particular the quantity of collagen within the papillary dermis, vasculature of the skin, distribution and quantity of melanin – especially relative to the dermo-epidermal junction - can be assessed in a rapid non-invasive manner. Studies have shown the usefulness of this approach in the assessment of pigmented and other skin lesions [9].

3. Construction of SIAgraphs

SIAgraphs are obtained by capturing eight filtered waveband images of a skin lesion extending from 400 to 1000nm. These waveband images are then calibrated and act as inputs to a series of computer algorithms that extract information regarding the microarchitecture of the skin [10].

First the algorithm utilises infrared wavebands to ascertain the quantity of collagen within the papillary dermis for every point over the skin lesion. This is the crucial step for this technique and provides a necessary transformation on the wavebands allowing accurate extraction of total melanin and blood. The total melanin, collagen and blood SIAgraphs can now be displayed.

The effect of these chromophores on the wavebands is then removed, thus allowing to identify the key diagnostic parameter, the presence of melanin below the dermo-epidermal junction. This is possible because the spectral remittance of melanin changes with regard to its position in the superficial anatomical layers of the skin, namely the epidermis and the papillary dermis. The sensitivity of detection is extremely high [10]. The presence of dermal melanin is shown on a SIAgraph. Information on the depth of melanin within the papillary dermis can also be returned in the form of a Clark's level.

4. Clinical evaluation

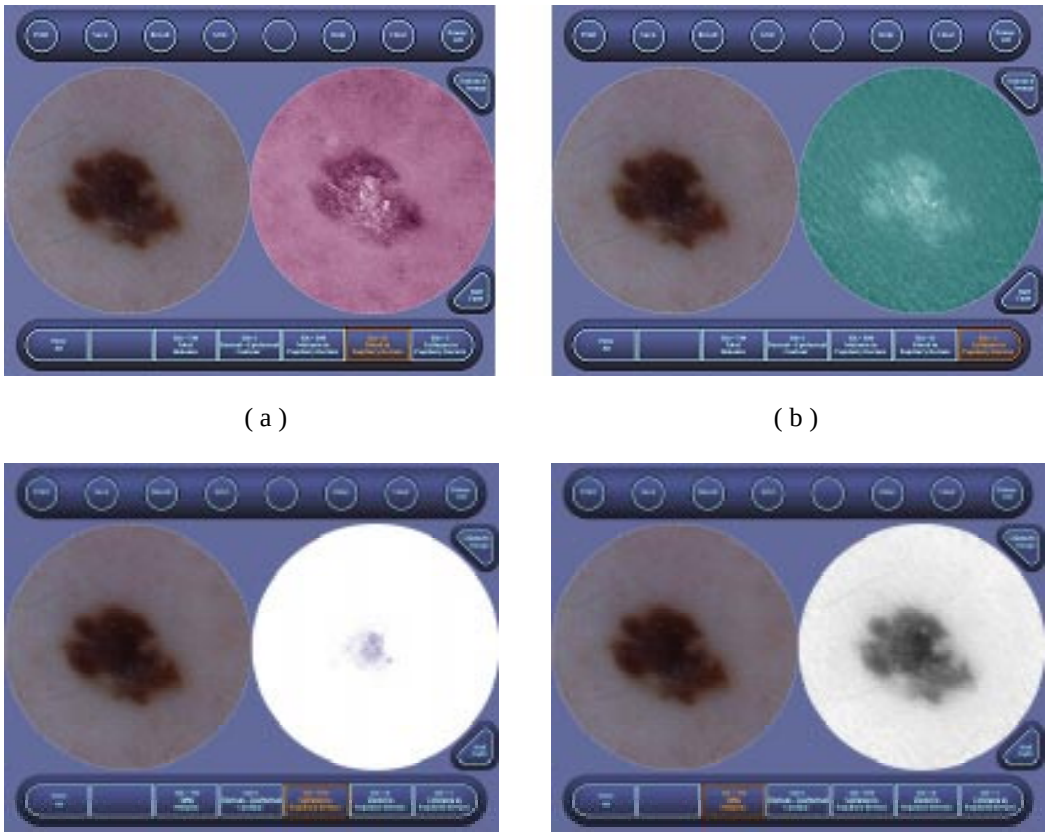
In clinical evaluation a dataset of 348 assorted pigmented lesions, including 52 melanomas, have been analysed to date (table 1).

Melanomas characteristically display combinations of the following features [11]: (1) An 'erythematous blush' at the invading margin of the superficial spreading lesion; (2) displacement of blood in the papillary dermis by invasive regions; (3) tumour punching holes in papillary collagen; (4) collagen arranged into rosettes and whorls around invasive nodules; (5) dermal melanin in haphazard arrangements in invasive regions. In contrast, benign naevi display a regular arrangement of dermal and epidermal melanin, a homogeneous vascular pattern and a homogeneous collagen arrangement.

These features can be seen in the SIAscope screen images shown below. A colour image of the skin lesion is shown on the left of the screen and one of the SIAgraphs is shown on the right hand side of the screen. Arranged top to bottom and left to right a blood SIAgraph showing an erythematous blush with displacement of blood; a collagen SIAgraph showing an increase of collagen within the lesion; a dermal melanin SIAgraph with the presence of dermal melanin indicated in blue and finally a total melanin SIAgraph indicating that this is clearly a melanocytic lesion.

Diagnosis	**Number**
Melanoma *- Superficial Spreading* *- Nodular* *- Acral Lentiginous*	52 *41* *9* *2*
Common Naevi (Compound, Junctional & Intradermal)	185
Dysplastic Naevi	7
Blue Naevi	12
Spitz Naevi	7
Seborrheic Keratoses	29
Lentigo	9
BCC	21
Dermatofibroma	8
Mixed Naevi	2
Haemangioma	2
Others	14
Total	348

Table 1



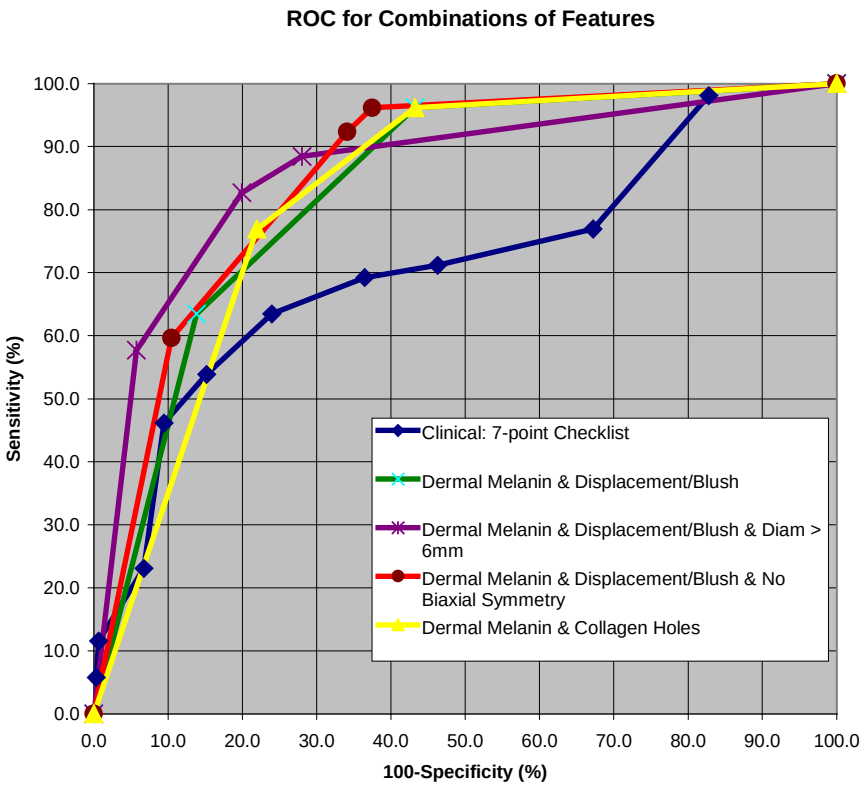
(a) (b)

(c) (d)

Figure 2: SIAgraphs (the colour image on the left, a SIAgraph on the right):
(a) dermal blood; (b) papillary collagen; (c) dermal melanin; (d) total (dermal and epidermal) melanin.

4. Results

Using the SIAscope, these new features identified in melanomas have been shown to be reliable and repeatable



[12]. When applying them to the diagnosis of melanoma, some of these features show a high specificity and whilst others a high sensitivity. However, on combining them using logistical regression analysis a sensitivity of 93% and a specificity of 80% can be achieved. The receiver-operator curves (ROC) constructed from these data can be shown to improve diagnostic performance when compared to dermatoscopy.

5. Discussion and future work

A unique information about the skin structure shown in SIAgraps can assist in the diagnosis of naevi and early malignant melanoma. Further on, this study will identify and assess features obtained using SIA technology and provide specificity and sensitivity to guide the physician in planning the management of their patient.

Although, as described, the SIAscope is a powerful tool in the identification of early melanomas, it can also aid the existing clinical interpretation methods. Currently melanomas are assessed either purely visually of by a dermatoscope which is a simple magnifying device. The differential diagnosis of pigmented skin lesions under the dermatoscope is necessarily subjective and operator dependent, relying on the visual interpretation of a colour dermatoscopy image. By separating out the individual components of the skin the SIAscope may reduce the subjectivity and training required for this analysis. A popular diagnostic "algorithm" utilised in the interpretation using dermatoscopy is that described by Stolz et al [13]. It proceeds as follows:

> Step 1 determines whether any of the structural components "pigment network", "pigmented aggregated globules" or "branched streaks" are present. As these structures are formed from the distribution of the pigment melanin their investigation using the melanin SIAgraph allows their examination free from the background components of the skin. The presence of these features indicates a melanocytic lesion.
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> Step 2 investigates the presence of "steel-blue" pigmentation typical of a blue neavus consistent with melanin within the papaillary dermis. Such structures can be clearly seen by examining the dermal melanin SIAgraph where dermal melanin should be seen filling the entire lesion.
>
> Step 3 investigates the presence of "red, blue-red and red-black lagoons" typical of haemangioma and angiokeratoma. Such lagoons being formed of blood show up very clearly in the blood SIAgraph allowing their differentiation from a melanocytic lesion.

In conclusion, by splitting an image of the skin into its component structural and compositional parts, the SIAscope assists in the diagnosis of melanoma. In particular it can increase the performance of practising clinicians in the early diagnosis of a deadly disease.

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