UNIVERSITATEA DE MEDICINĂ ȘI FARMACIE ”CAROL DAVILA”, BUCUREȘTI

SCOALA DOCTORALĂ

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Aplicațiile imagisticii hiperspectrale în medicină

REZUMATUL TEZEI DE ABILITARE

(în limba engleză)

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ABSTRACT

The present thesis covers 10 years of activity, starting in 2014, when I was conferred the title of Ph. D. It consists of 4 parts: scientific activity, academic activity, professional activity and plans for the future.

The scientific activity of this period was dominated by the theme of medical applications of *hyperspectral imaging (HSI)*. Hyperspectral imaging is a modern technique that provides both spectral and spatial information about the investigated scene. The image contains the reflective spectra of each pixel, gathering a huge amount of information, which is called a *hypercube.* The way this information is analyzed in order to obtain essential data poses the greatest challenge. Together with a group of researchers from National Institute for Research and Development in Opto-Electronics lead by Mrs. Mihaela Antonina Calin, I started to investigate several applications of this technique in medicine.

The first article tried to characterize a wound of the hind leg of a dog from a vet clinic [1]. We used *mixture-tuned matched filtering* (MTMF) method for analyzing the HSI of the wound. The method allowed us to identify several types of tissues with a good match from the map of the wound that was generated with the MTMF.

This was followed by 5 studies regarding burn wounds. The first one [2] tried to characterize a burn wound on the leg of an old lady using linear spectral unmixing analysis. Although some areas in the generated map were not assigned any characteristics and some types of tissue were seen as different, the study demonstrated that HIS could be used for burn characterization. A second study [3] defined a burns index based on spectral differences between normal and burned skin and compared the maps generated with K-means clustering with laser doppler scans of the wounds in 9 patients. A confusion matrix was used to compare the two methods, and the result confirmed the usefulness and accuracy of our method. We continued by comparing support vector machine (SVM) and spectral angler mapper (SAM) – two supervised classifiers – in generating maps from HS images of a burn [4]. A confusion matrix was used for comparison, and SVM gave slightly better results. Because HSI processing includes a noise reduction phase, we compared 5 denoising methods for HSI of burn wound: wavelet transform, principal component analysis, Gamma filter, Lee filter, and minimum noise transform [5]. Gamma filter behaved best, followed

by Lee filter. In the last study regarding burns, a classification method based on segmentation leading to "objects" that generated maps of the burn used was tested [6]. SVM was used to produce burn wound maps. An area based error matrix was used for testing the accuracy. The study provided good results.

Going further in studying skin properties, we designed an algorithm based on the Beer-Lambert law that can provide maps of distribution of oxy- and deoxy-hemoglobin concentration of a skin area [7]. This allowed us to monitor a sural distally based flap during the first 48 hours postop and characterize its evolution [8]. The same algorithm was used to monitor changes in oxygenation of the forehead of healthy volunteers during hypoxia and recovery [9]. The method allowed us to demonstrate an interesting adaptation to hypoxia with vasodilation in the internal carotid system at the beginning of the hypoxia period. We use the algorithm to test the effect of photobiomodulation on skin oxygenation in healthy persons, and we demonstrate that the regimen we tested had no effect [10].

Studying skin tumors was a logical pursuit. In a first study on this subject, we demonstrated that HSI and Reed-Xiaoli anomaly detector (RXD) or Reed-Xiaoli/Uniform Target hybrid detector (RXD/UTD) can automatically detect a basal cell carcinoma of the lower lip [11]. In a larger study in which HSI was applied to 36 skin tumors (actinic keratoses, seborrheic keratoses, basal cell carcinomas, squamous cell carcinomas), we found out that an index based on the angle of the spectral curve at 583-600 nm could reliably differentiate the type of tumor that was investigated [12]. In another study, we delineated the margins of non-melanoma skin cancers from HSI using segmentation and SAM classifier to produce preop maps which can help the surgeon in deciding that extent of excision [13].

We also used HSI to determine some physiological properties of the skin: evolution of skin texture with age [14] and mapping the melanin concentration in certain skin areas [15]. The latter allowed for clear differentiation among I to IV Fitzpatrick's skin phenotypes in a study on healthy young volunteers.

My scientific activity during this period was also directed to automatic computer assisted interpretation of whole-body bone scintigraphy images using the parallelepiped classification method [16] and an objected oriented approach [17] with good results. I investigated the tumor excision margins for basal cell carcinomas of the nasal pyramid in a retrospective study and their

connection with insufficient resection and demonstrated that lower margins were applicable [18]. I participated in several other studies where my contribution was lower than in the studies described before: an experimental model on rats to evaluate the regeneration of operated defects of the sciatic nerve based on multiple methods including MRI [19], a study of the economic impact of radiotherapy on delayed breast reconstruction with both implants or autologous tissue [20], and a review of the hypoxia inducible factors in acute kidney injury of patients with large burns [21].

This scientific activity led to a Hirsch index of 11 on Web of Science, invitations to numerous peer-reviews of manuscripts and my invitation to become an associate editor in the Editorial Board of Plastic and Reconstructive Surgery Global Open, among other recognition.

The academic evolution during this period was from Assistant Lecturer to Associate Professor, head of discipline, and residency program director. I improved the didactic materials and made the step towards on-line teaching during the pandemic restrictions. Together with the other members of the discipline, we started a program of video demonstrations of various interventions dedicated to residents in plastic surgery. I participated in numerous examination boards at all levels (admission into Faculty, admission in the residency program, exams for occupying new positions at the Faculty or in the public health system).

The professional activity progressed through addressing new pathology, while becoming head of surgery in the 2nd department of plastic surgery of the hospital. I also fulfilled a 2 week fellowship in treating burns in 2022 at Hopital Roger Salengro, CHU Lille, France. I became a member of the Health Ministry's Commission for Plastic Surgery since 2022.

The first objective for the future is to occupy the position of Professor, while continuing my efforts in research, teaching to students and residents, and improving my portfolio of techniques.

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