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Monitoring Of Capillaries In Occupational Exposure As Biological Indicator In Radiation Protection

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INTRODUCTION

A non-invasive methode to accomplish the morphological analysis of micro-circulation is the use of video-capillaroscopy, that is the visual inspection of microscopy sequences of the capillaries. As capillaries are notoriously sensitive to ionizing radiation, workers exposed in the university undergo a capillaroscopy examination during their periodic check-ups for medical surveillance.

Radiation-induced alterations in capillaries and microvessels are threshold effects and depend on dose. Video-capillaroscopy can be meaningful in cases where the dose threshold has been exceeded in accidents of irradiation of the skin, in particular on the area of the hands or in the other anatomical areas also mucous membranes, as bulbar conjunctiva, in witch capillary network is in vivo visible and computable.

In subjects exposed to radiation, video-capillaroscopy can also be generically meaningful relative to the state of perfusion of tissues as well as indicative of a normal defence mechanism and of protection from external harmful agents.

METHODS

In the last five years medical surveillance using *in vivo* biomicroscopic biological monitoring of capillaries was carried out in 247 workers 130 of which subject to surveillance dosimetric of Naples University Federico II. These workers had been exposed to radiation sources constituted by a particle accelerator, RX Diffractometer, electronic microscope and radionuclides of low energy (32P, 35S, 7Be, 3H, 125I, 32P, 14P, 14C, 33Y, 241Am, 55Fe, 109Cd, 57Co, 88Y, 226Rn, 133Ba, 137Cs, 60Co, 210Pb, 109Cd, 22Na). An operational protocol was adopted. According to this protocol workers exposed to radiation undergo *in vivo* an examination of the microvessels of the skin using a 'Videocap' (DS-Medica, Milan) video-capillaroscope with optical probes of 50x, 100x, 200x with reference to the characteristics of capillaries as to (Figure 1)

- number (normal, reduced, increased);
- morphology (normal, thinned, twisted, ectasia);
- distribution (normal, irregular);
- microcirculation (normal, granular, sludge, stasis);
- subpapillary network (visible, not visible, accentuated);
- particular aspects (megacapillaries, microaneurisms, haemorrhages).

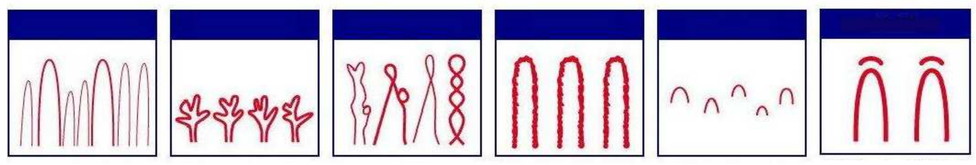


Figure 1 The morphology

For biological monitoring of the body zones in the subjects exposed to ionizing radiation, the authors propose the use of this microvascular quantitative analysis together with dosimetric monitoring. The application of new informatics technologies to capillaroscopy using biometric system for purpose of biological dosimetry enable us to increase the sensitivity of the microvascular and hemoreological investigation and to give markers of tissues perfusions useful for evaluating the health conditions of the exposed subjects.

The algorithms developed include ad hoc techniques for image registration and segmentation. A set of algorithms (Figure 2) has been implemented for working on video sequences for exploiting the all visual information that would be lost in a single snapshot. A second set of algorithms aim to remove possible artefacts and highlight the capillaries for the next feature extraction step.

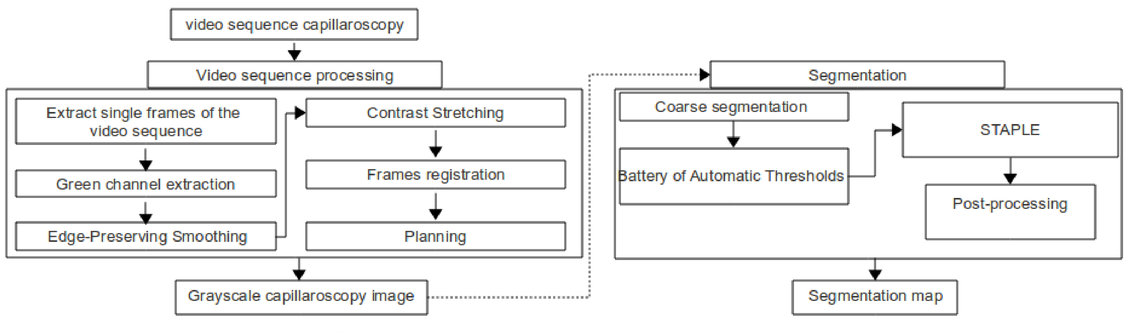


Figure 2 The processing pipeline of the proposed system.

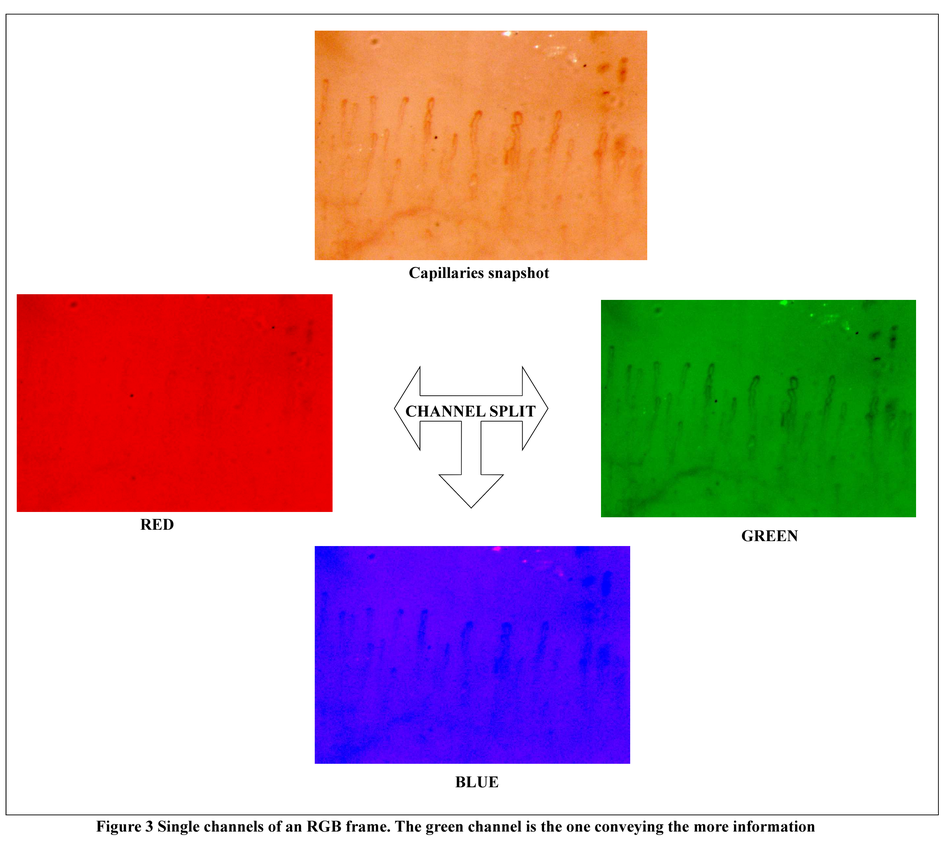
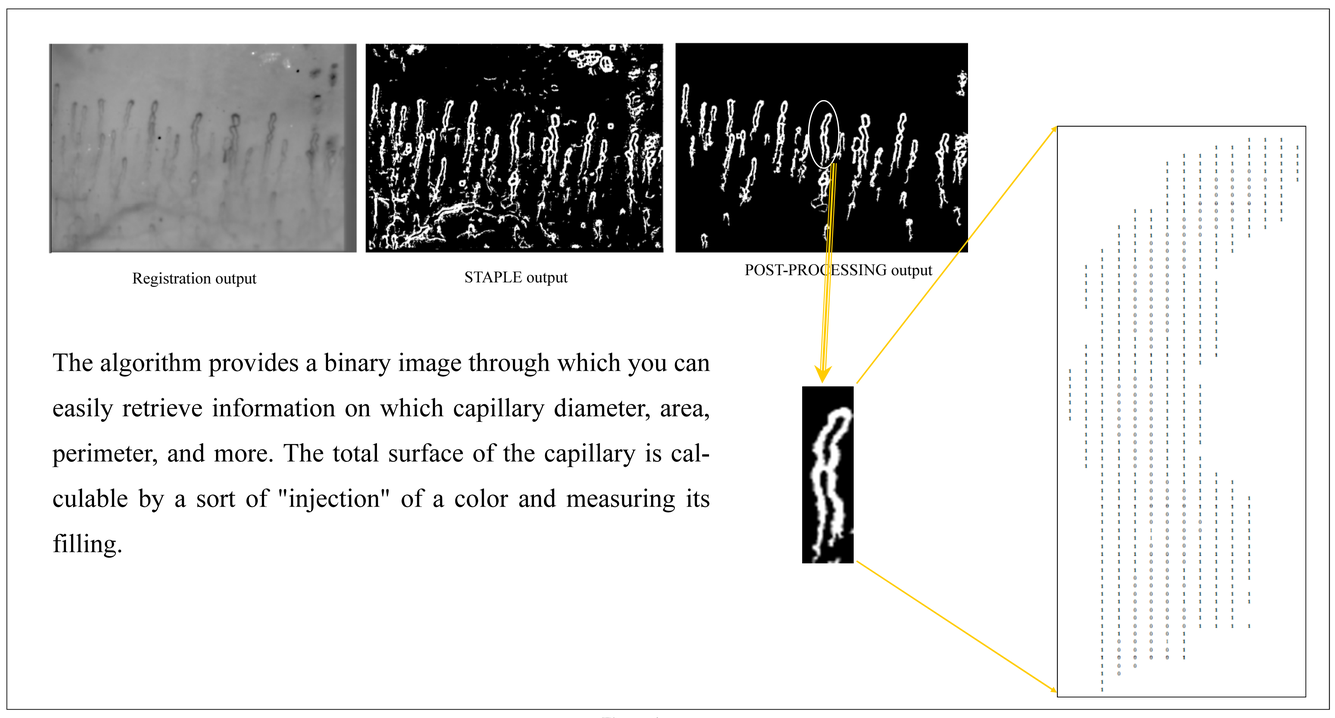


Figure 3 Single channels of an RGB frame. The green channel is the one conveying the more information

The first logical module of the pipeline depicted in Figure 2 produces from the video sequence acquired during the examination a single image where the capillaries are more visible than in each single frame. As it is done in most of the literature we decided to consider only the green channel of the original RGB frames, because it is the most informative channel, as shown in Figure 3.

At the end of the algorithm is possible to extract objective data of the capillaries, as shown in Figure 4. The new technique of the acquisition of the video sequence results in an improvement in the evaluation of blood flow with a net improvement of the edges of the capillaries.



The algorithm provides a binary image through which you can easily retrieve information on which capillary diameter, area, perimeter, and more. The total surface of the capillary is calculable by a sort of "injection" of a color and measuring its filling.

Figure 4

RESULTS

The profile of the examined workers during capillaroscopic monitoring has been defined as having a normality of grade 0 or classified non significant. The doses of radiation absorbed by people who are legally classified as being "exposed" proved to be frequently below the levels of those in the normal population under effective dose limit for public exposure (1 mSv/y) (Table 1).

YEAR	Dose < 1 mSV	1 mSv < Dose < 2 mSV	2 mSv < Dose < 6 mSV
2006	68%	32%	0%
2007	100%	0%	0%
2008	100%	0%	0%
2009	100%	0%	0%
2010	100%	0%	0%

TABLE 1

The clinical and biological data have shown the healthiness of the workers exposed to ionising radiation. The capillaroscopic examinations in the localized expositions of the skin in the periodic control have generally given good perfusion of the exposed tissues, integrating the health concept and has been considered as biological indicator of good response to ionising radiation.

CONCLUSIONS

The video-capillaroscopy together with appropriate computer applications, that is the proposed software for the segmentation of the capillaries from video sequences, have given us a true qualitative leap in diagnostic imaging techniques in the purpose of the radiation protection. The results of dosimetric analysis of those who are exposed to ionizing radiation in the medical environment of traditional radiology are satisfactory. All of these elements show the need to develop a biological exposure indicator that guarantees the maintenance of good health of exposed workers; that is in keeping with the philosophy and practice of radioprotection. Results may lead to improved prevention with a specific monitoring protocol that uses capillaroscopic exam as indicator of biological risk and also indicates a particular sensivity to radiation on the part of an individual.

Research data will let us better watch over the health of workers and help guide our actions in cases where dose has been exceeded or where there has been significant biological alteration.