Introduction

Visualization of blood vessels is a fundamental task to evaluate the health and biological integrity of the tissue. Laser Speckle Contrasts Imaging (LSCI) is a non-invasive technique to determine the blood flow in superficial or exposed vasculature. However, the high scattering of biological tissue, hinder the visualization of those structures. In this paper, we propose the use of Principal Component Analysis (PCA) in combination with LSCI to improve the visualization of deep blood vessels. Using PCA, it be separated and filtered by selecting the most significant principal components. This analysis was applied to in vitro samples, and our results demonstrate that this approach allows the visualization and localization of blood vessels as deep as 1000μm.

Laser speckle imaging

The local contrast $K$ [1], is computed typically in a sliding window of 5x5 pixels through the equation

$$K = \frac{a - c}{c}$$

where $σ$ is the standard deviation and $<I>$ is the mean intensity of the pixels in the sliding window, this local contrast value is assigned to the central pixel.

The contrast equation (1) can be expressed [2] as a function of the correlation time $τ_c$ of the backscattered light from the sample and the exposure time $T$ of the CCD camera[3]:

$$K^2(x) = \beta^2 \frac{\exp(-2x) - 1 + 2x}{2x^2} + 4\beta^2(1 - \rho) \frac{\exp(-x) - 1 + x}{x^2} + \beta(1 - \rho)^2$$

where $x \equiv T/τ_c$, $ρ$ is the fraction of the dynamically scattered light and $β$ is a correction factor that depends on the ratio of speckle and pixel size. When $x ≫ 1$, the contrast reaches an asymptotic value ($K_0$) given by:

$$K^2(x)_{x≫1} ≡ K^2_0 = \beta(1 - \rho)^2$$

Separate out $K^2_0$ from $K^2_0$ and therefore improve the visualization of deep blood vessels.

PCA

PCA is a statistical technique that uses an orthogonal transformation to describe a set of correlated observations in terms of new uncorrelated variables, called principal components (PC’s), which are linear combinations of the original variables [4]. The procedure to obtain the PC’s begins with the organization of the data in a matrix $Γ$ of dimension $M \times N$. Here $M$ represents the number of observations and $N$ the number of variables.

Materials and method

Figure 2 a) LSI system, b) top-layer thicknesses[5] (T1s) of $δ = 0.190, 0.510, 311 and 1000 μm$. We used a syringe pump to infuse intralipid at 3% in water as a blood substitute into the channel at speed of 5 mm/s, glass capillary tube, with an inner diameter of 550 μm and Region of Interest (ROI) centered .