Automated data and image processing for biomedical sample analysis

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***Abstract*— Terahertz (THz) imaging and tomography are modern imaging techniques permitting 2D and 3D inspection of objects over a broadband frequency range. The enormous quantity of information is then obtained. To be analyzed efficiently, an automated 3D data and image processing tool is needed. We present a complete data and image processing sequence to perform non-destructive inspection obtained from time domain spectro imaging. We implement numerous parameter choices, compressive data mining, imaging processing to analyze samples. Example of** advanced processing sequence for 3D THz imaging for cancer detection in paraffin embedded breast cancers will be presented.

I. INTRODUCTION

In the field of non-destructive testing (NDT), terahertz (THz) imaging is an emerging technique providing 2D or 3D images of an object from the THz radiations (between 0.1 and 10THz) reflected or transmitted through the sample.

Many studies have demonstrated the potential of terahertz imaging and spectroscopy to probe the macroscopic level of cancer [1, 2]. Research to increase data acquisition speed, improve penetration depth, and improve image contrast are some key areas that must be addressed if terahertz technology is going to become a tool for clinicians in the future.

In this context, it 's necessary to implement advanced data[3, 4] and image processing [5]. For time domain spectroscopy case, we implement automated data processing: The segmentation of this type of images makes possible the discrimination of diverse regions within a sample. To develop this aspect, we integrate advanced visualization and classification methods [6] which allow us extracting efficiently, the information of interest in a huge quantity of collected data. Many studies have demonstrated the potential of terahertz imaging and spectroscopy to probe the macroscopic level, for example in images of cancer, and the molecular level, such as in protein spectroscopy but many problems still remain. Research to increase data acquisition speed, improve penetration depth, and improve image contrast are some key areas that must be addressed if terahertz technology is going to become a tool for clinicians in the future. In this context, it 's necessary to implement advanced data and image processing to discriminate the "benign" or "malignant" diagnosis of tissues under investigation.

In this work, we present a complete image processing sequence for spectro imaging. Example of different images of the same breast cancer tissue will be presented. They were obtained by THz reflection imaging of the paraffin block, reflection and transmission of 30μm onto a sapphire window, and they are compared to histopathological samples.

II. RESULTS

In this study, we will focus on the identification of tumors of embedded breast cancer. The sample is fixed in formalin, dehydrated, and embedded in paraffin. The thickness is 20-30μm and deposed on a sapphire window. We perform reflection imaging of the same samples plus directly onto the paraffin bulk sample. During interaction between THz beam and the sample, the transmitted or reflecting THz pulses experience temporal delay, attenuation and broadening with respect to the reference pulse measured without the sample or through a sample substrate placed into the THz beam. These pulse changes are caused by either one or several of the following physical processes in the sample which are generally frequency dependent: absorption, optical thickness reflection of THz radiation at the sample frontiers, scattering and diffraction effect out of the direct propagation direction. To extract pertinent information, various visualization techniques based on time-domain data will be given and on the other hand, the data for each pixel can be Fourier transformed to extract frequency-dependent properties of the sample and used improved spatial resolution found at higher frequencies. So a lot of combinations could be tested. We automate various visualization techniques based on time-domain data and frequency domain. Moreover, we add some statistical tools such as principal components analysis and Shannon Entropy (Fig1.)

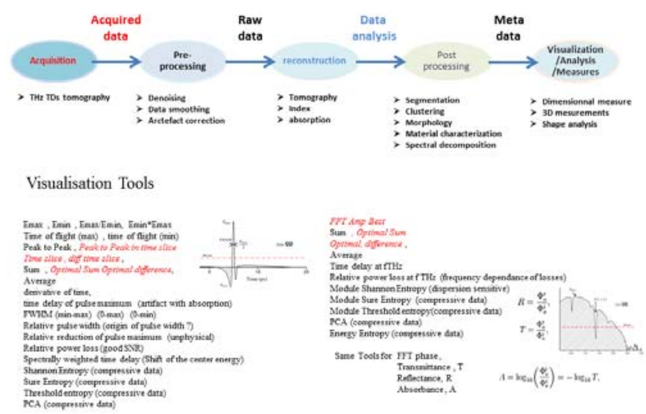
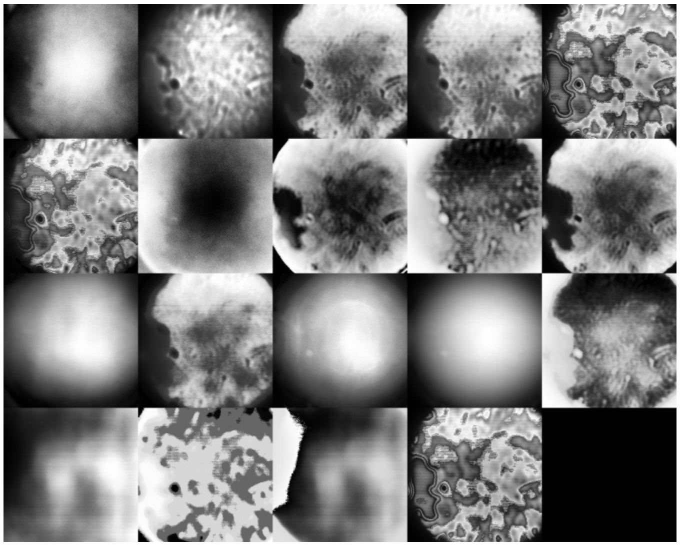
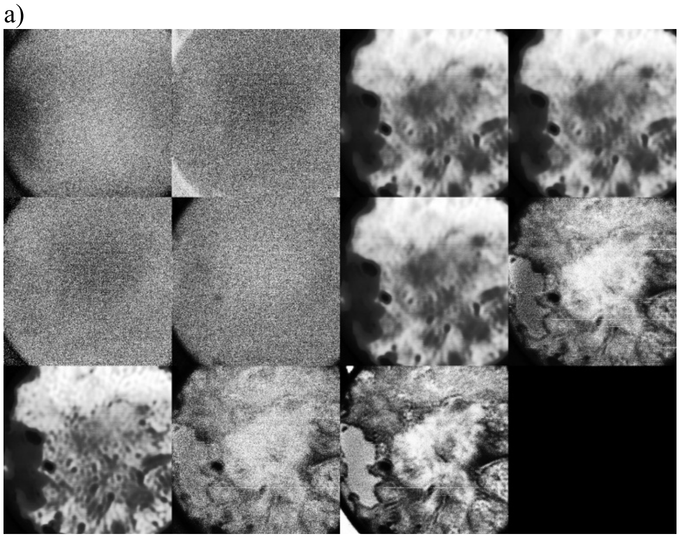


Fig. 1 Data and image processing sequences implemented

A systematic comparison will be presented for reflection and transmission images in time domain , amplitude and phase in frequency (Fig.2).



a)

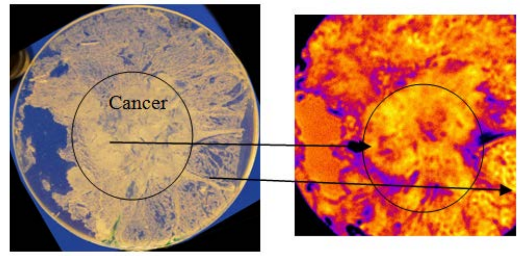


b)

Fig. 2 : example of automatic extraction of different images obtained by data processing in time domain(in order from left to right: Time domain difference, Time domain div, Energy Entropy,FWHM Max, Mean, Min, Multiplication, Relative Power loss, Relative pulse width, Reduction of pulse maximum, Time domain Shannon entropy, Spectrally weight time delay, Sum, Sure entropy, Threshold entropy, Time delay of pulse maximum a) and frequency domain

Then, this procedure allows extracting quickly the pertinent area of interest and the best combination of parameters to put in evidence terahertz spectroscopic images of cancer tissues. By applying the clustering analysis, the systematic diagnosis of the disease area was realized. We emphasize that this method works complementally to the diagnosis done by medical doctors using the optical microscope because the clustering does not specify which the cancer area is. In addition, the cancer tumor cannot always be distinguished by the terahertz spectra.

Figure 3 is a false color representation of the sample giving a optimized contrast. A remarkable correlation can be found between optical and Terahertz imaging.



a) b)

Fig.3: an optical picture of the tissue under investigation and b) best frequency amplitude THz image.

III. Summary

In conclusion, terahertz spectroscopic images of cancer tissues have been recorded by a terahertz time domain spectrometer and processed using the direct reflection and transmission data on different prepared samples. This THz observation correlates well with the histopathological images However, to accurately assess tumor margins, rigorous protocols for sample preparations are needed and we will perform and test the automated sequences on freshly excised samples. More research for the particular sample type is necessary. This tool presents a great interest for systematic identification of cancer tumors and could be extended after a precise extraction of the dielectric properties of the sample[7] .

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