Registration and Fusion Issues in Multisensorial and Multispectral scanning

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Outline

- Introduction
- Multimodal and multispectral data acquisition
- Image Registration
  - Area-/Correlation-based registration
  - Feature-based registration
  - Hardware registration
- Data Fusion

Introduction

Objective

- Registration of images originating from different modalities.
- Provide information richer images, as well as free of redundant information data sets, via fusion techniques.

Data Acquisition

- Utilization of the different implemented modalities, e.g. visual or IR cameras and UV/VIS, FTIR of Ultrasound multispectral mappings.

Challenge

- Selection of the proper registration technique for each image type produced using the Scan4Reco prototype.

Brief description of scanning modalities

Elctromagnetic modalities;

- **Infrared (IR) spectroscopy/scanning**; realized with the Bruker™ ALPHA FTIR Spectrometer and the Xenics™ XMID-FPA-640 IR Camera.
- **Raman or inelastic spectroscopy**; realized with the BWTek™ DualRam 785nm/1064nm Raman Spectrometer.
- **Ultraviolet (UV)/ Visual (VIS) scanning**; realized with the Avantes™ AvaLight-D(H)-S Deuterium-Halogen light sources and AvaSpec-2048TEC optic spectrometer.
- **X-Ray Fluorescence (XRF);** realized with the Niton™ XL3t GOLDD+ XRF Analyser.

Mechanical modalitites;

- **Ultrasonic microscope;** realized with the 110 MHz/ 175 MHz Olympus™ transducers, the Panametrics-NDT™ Model 5910R 400MHz Pulser/Receiver and the A/D Converter Card AlazarTech™ ATS9373.

Mechanical Adaptation

- Two axes consist of two stages of 1250 mm length each with a total travel of 1000 mm (ATS60105 Aerotech motion system).
- One axis, with a total travel of 200 mm (Aerotech motion system ATS100-200).
- Θ (theta) angular movement (BMS60 Aerotech rotary stage), embedded onto the mechanical arm. Φ (phi) angular movement (Zaber X-RST-DE rotational motor).
- The control unit of the unified platform, the drives of the mechanical stages and the components of the integrated modalities are safely placed into two metallic racks.

Image Registration

Image registration is the procedure of transforming different sets of data into one coordinate system.

Areas of application

- Change detection
- Image mosaicking
- Medical tomographic imaging
- Computer vision
- Integrating information into geographic systems and cartography

Registration methods process steps

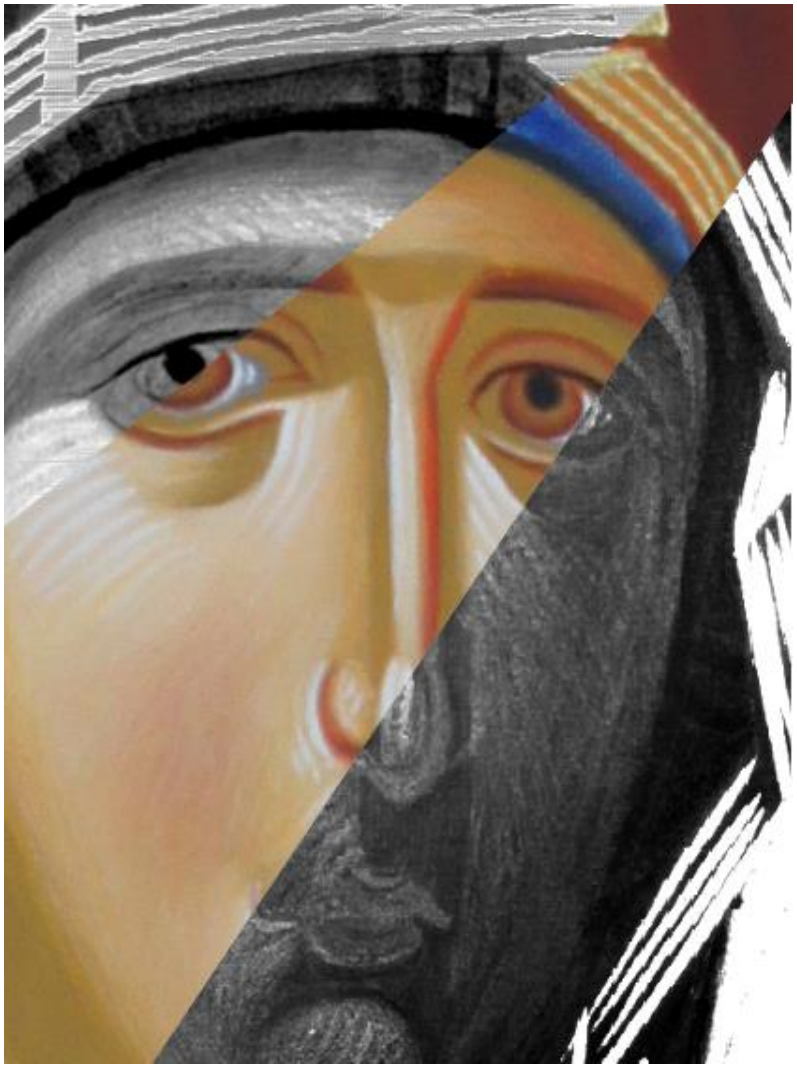
- Feature detection
- Feature matching
- Transform model estimation
- Image resampling and transformation

Area-based Registration

- The visual image is set as *fixed* and the IR one as *moving,*
- For both images, a number of points are manually selected, around of which areas of 32x32 pixels^2 are selected for **cross-correlation** procedure.
- The moving image is *algorithmically transformed* and placed upon the fixed image

Area-based Registration

Registration of different wavelength IR images onto visual ones



Area-based Registration

Registration of different visual and IR images

Area-based Registration

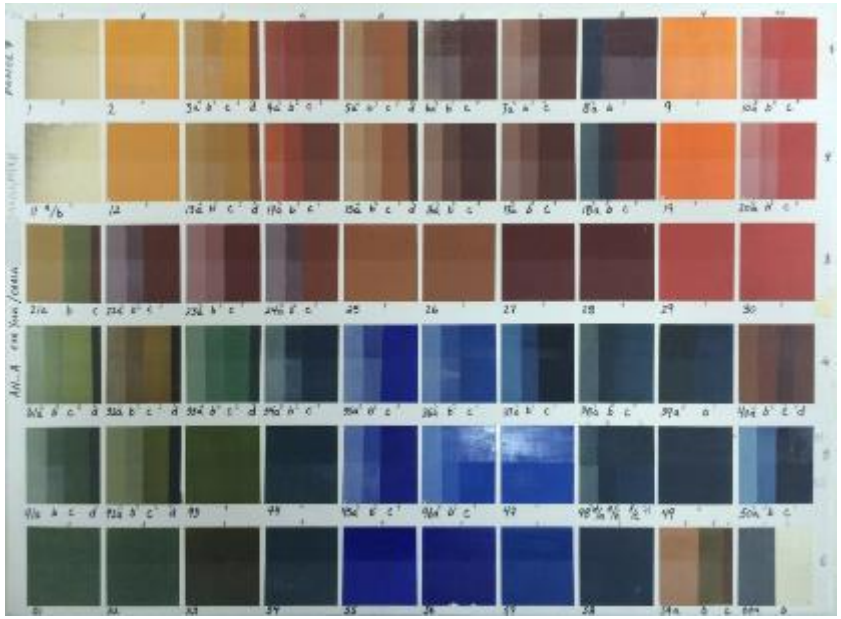
Area-based Registration

Image mosaicking;

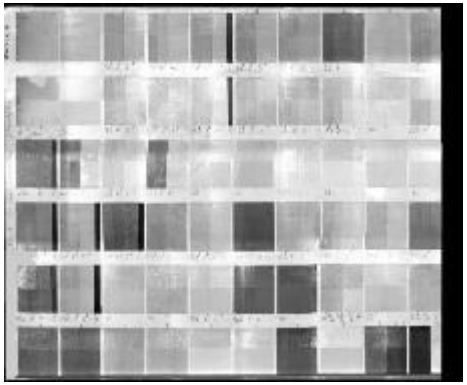
Creating high resolution IR images

Area-based Registration

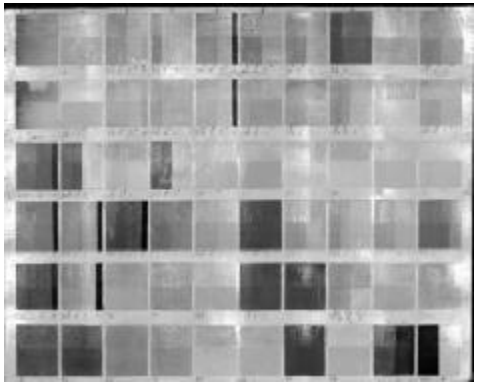
Registration of visual and different temporal IR images



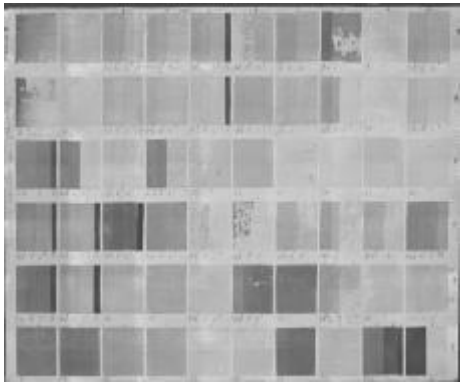
Visual – T0



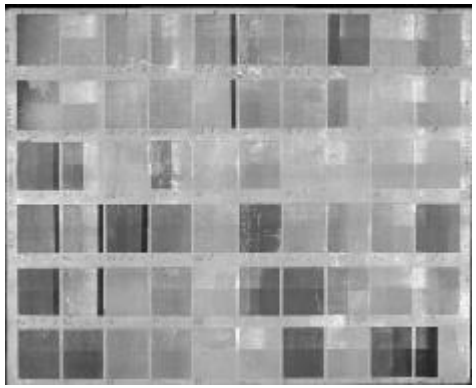
T0



T1



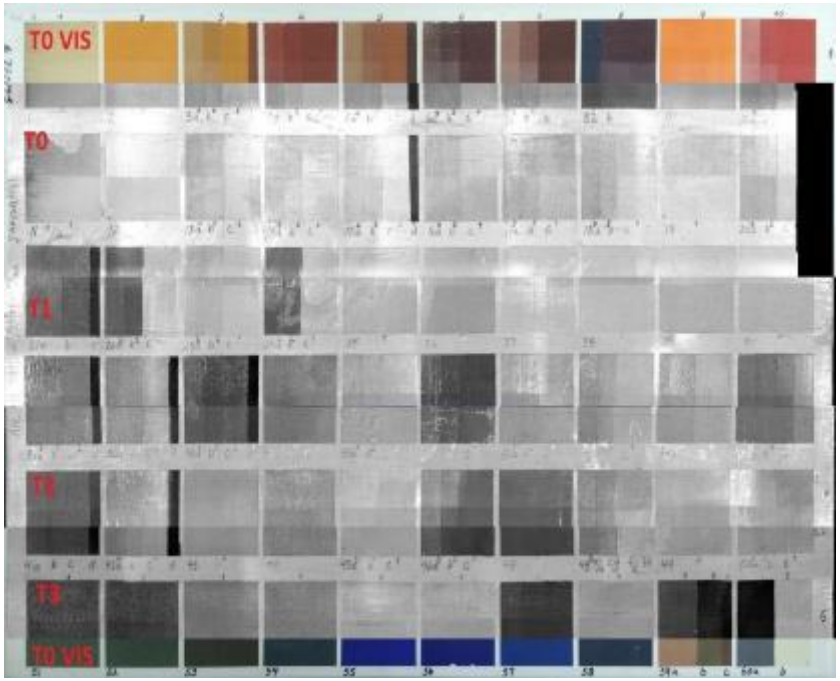
T2



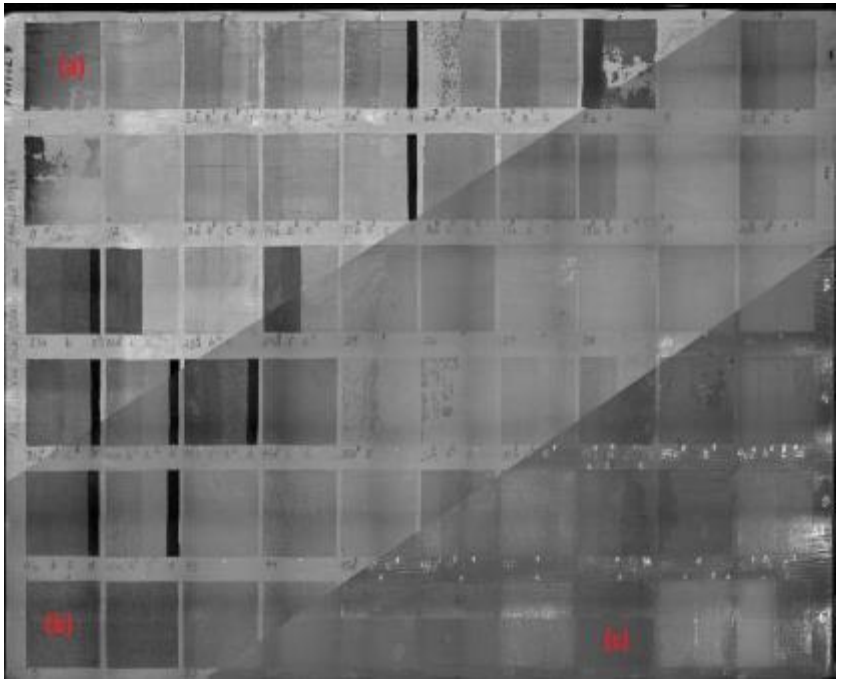
T3

Area-based Registration

Registration of visual and different temporal IR images



Registration of different wavelength IR images



Feature-based Registration

Feature detection stable under image transformations and encoding algorithms

- **SIFT**, **SURF**, **ORB**, BRISK, Corner Harris, FAST, FREAK and BRIEF .

Iterative algorithms to robustly estimate the parameters of a particular **image transformation** type for registration.

- **RANSAC** (RANdom SAmple Consensus).

Feature-based Registration

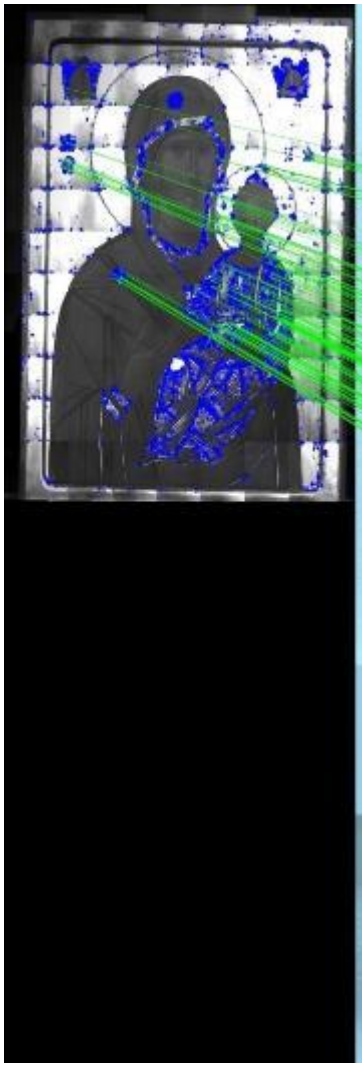
Registered IR and Visual images using SIFT feature detector

Feature-based Registration

Registered IR and Visual images using SURF feature detector

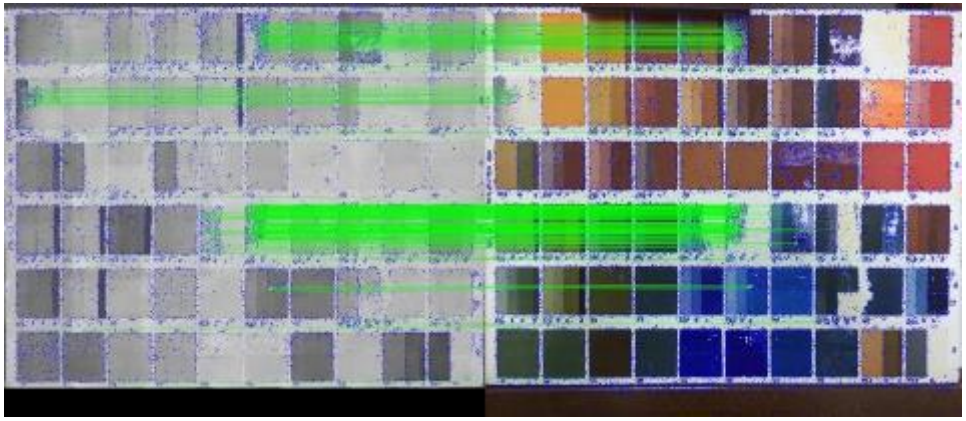
Feature-based Registration

Registered IR and Visual images using ORB feature detector



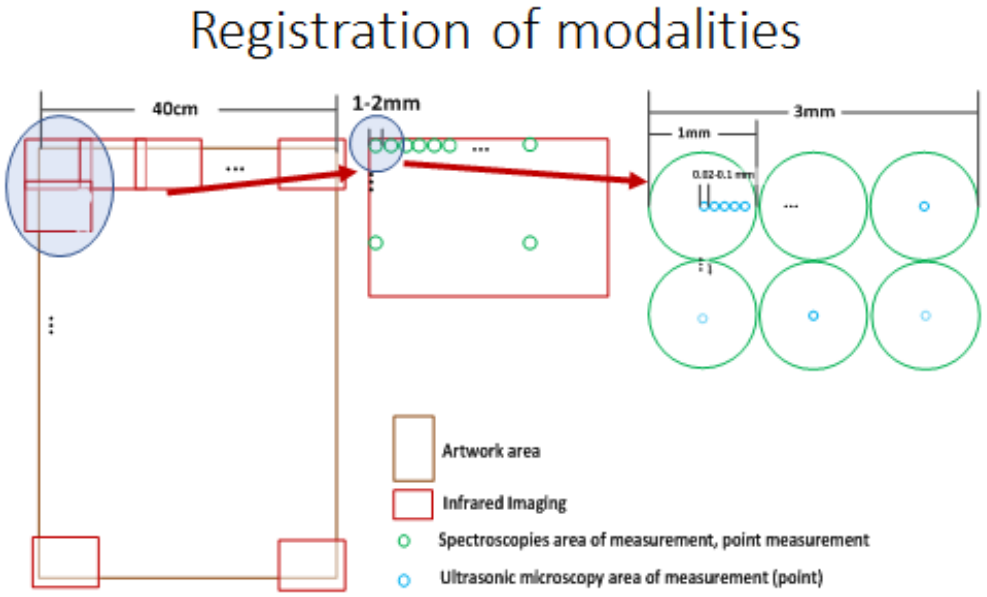
Feature-based Registration

Registered T3 Visual and IR via matched SURF features



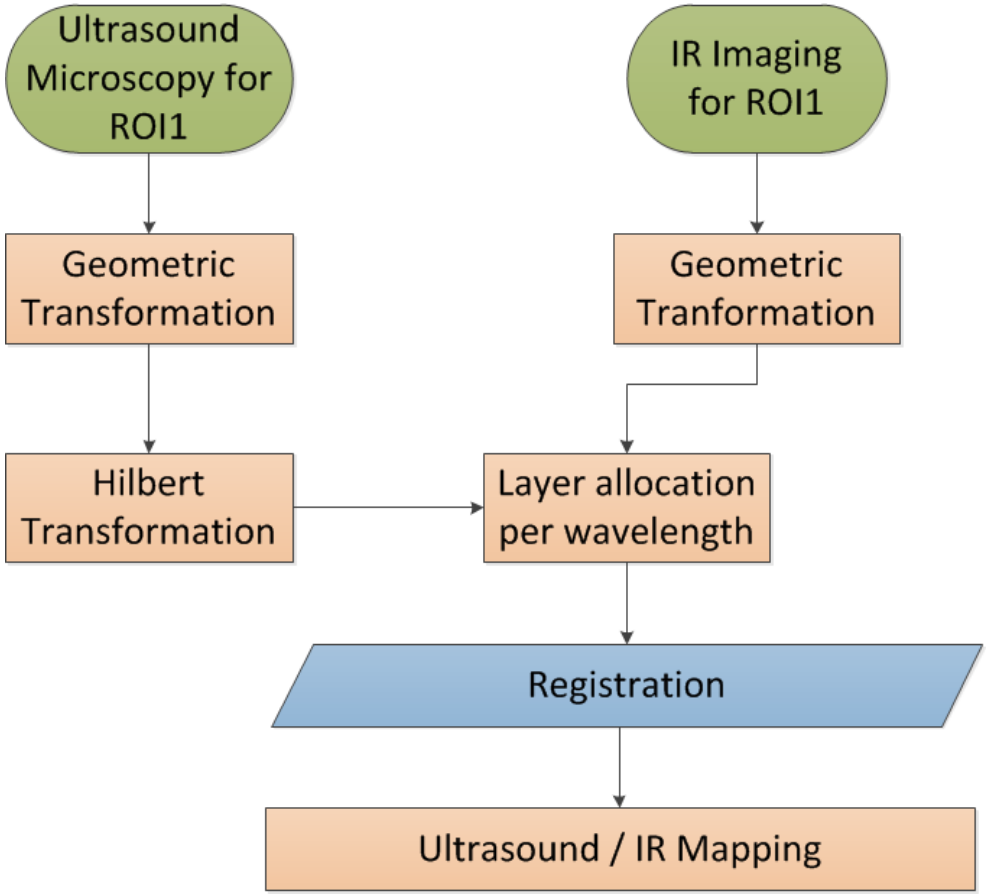
Hardware-based Registration

A very high accuracy of the mechanical arm is a powerful tool for conducting registration using the control points from the positions of the axes.



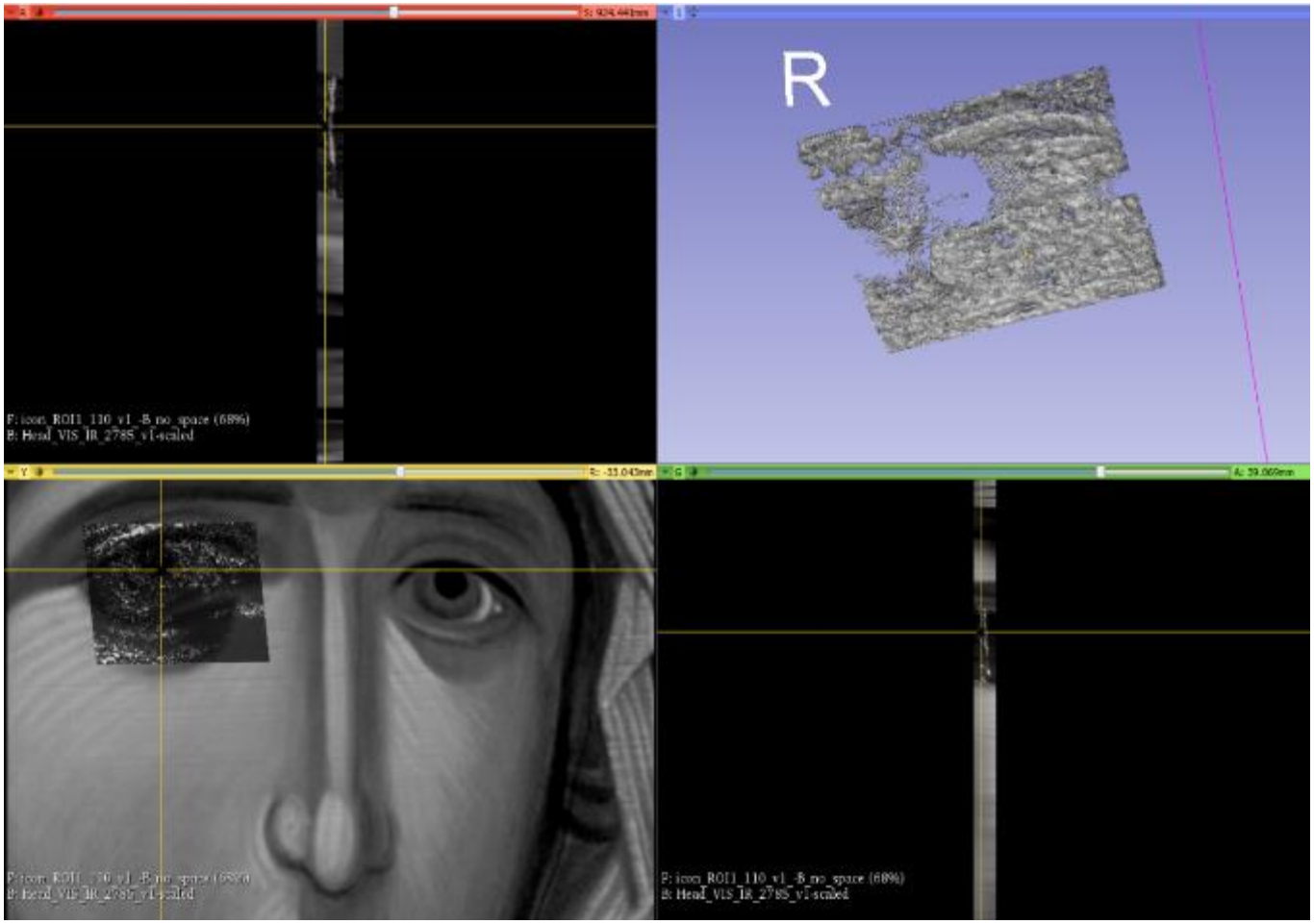
Hardware-based Registration

Flow chart of hardware-based registration



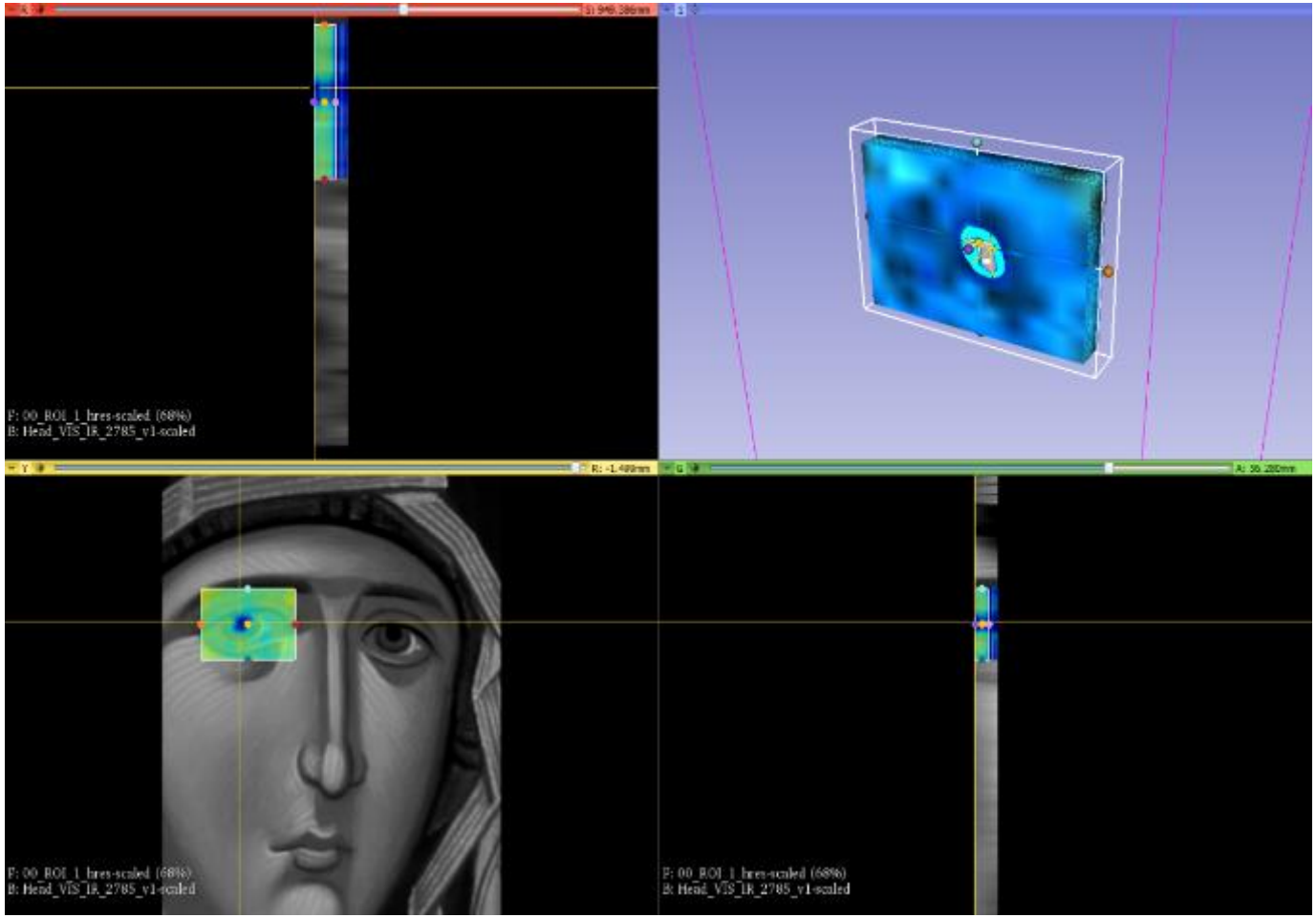
Hardware-based Registration

Ultrasound mapping image registered onto the IR image for the Mother of God head detail via Slicer 3D.



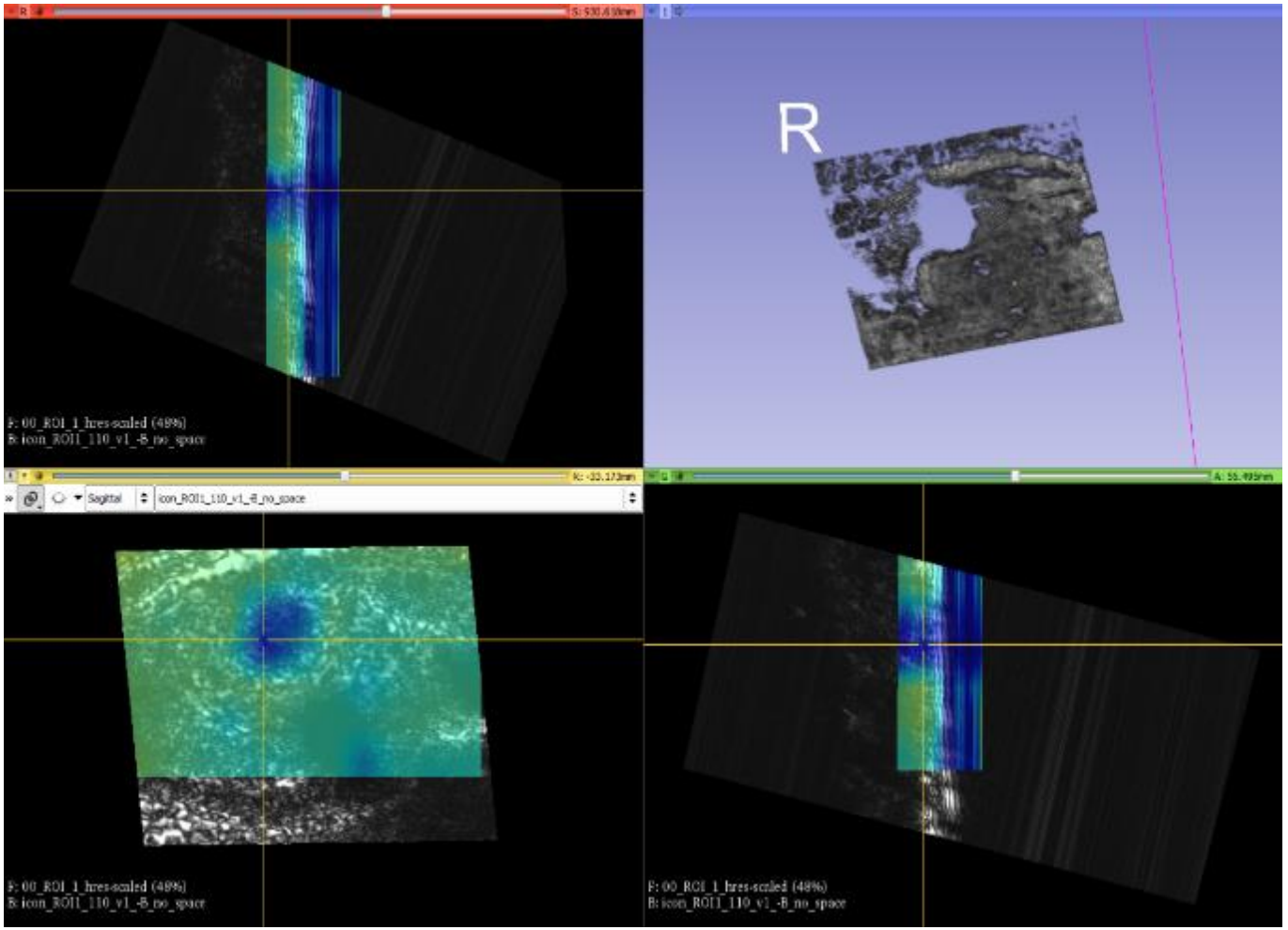
Hardware-based Registration

FTIR mapping image registered onto the IR image for the Mother of God head detail via Slicer 3D.



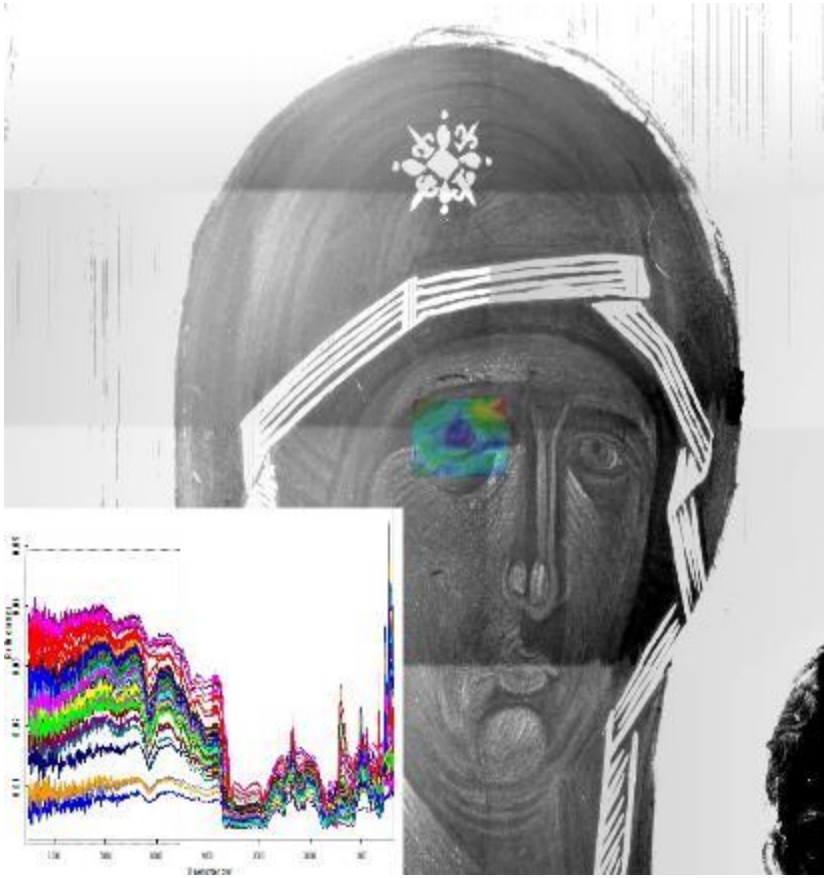
Hardware-based Registration

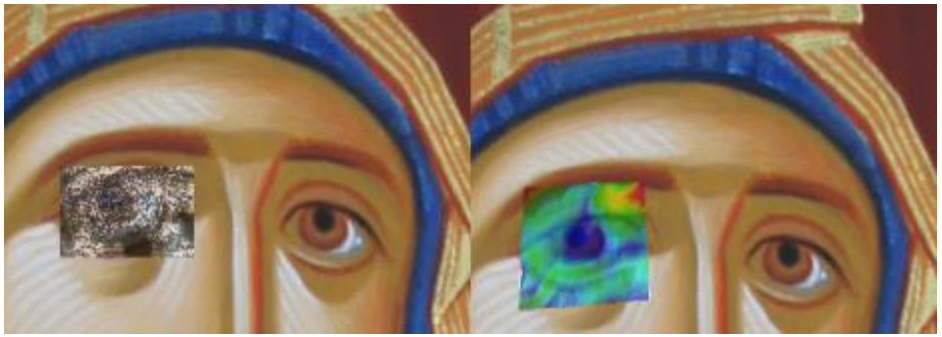
FTIR mapping image registered onto the Ultrasound mapping image for the Mother of God head detail via Slicer 3D.



Hardware-based Registration

Registration of a moving FTIR mapping image over an IR one at 2.87-5µm wavelength region.





visual and ultrasound images

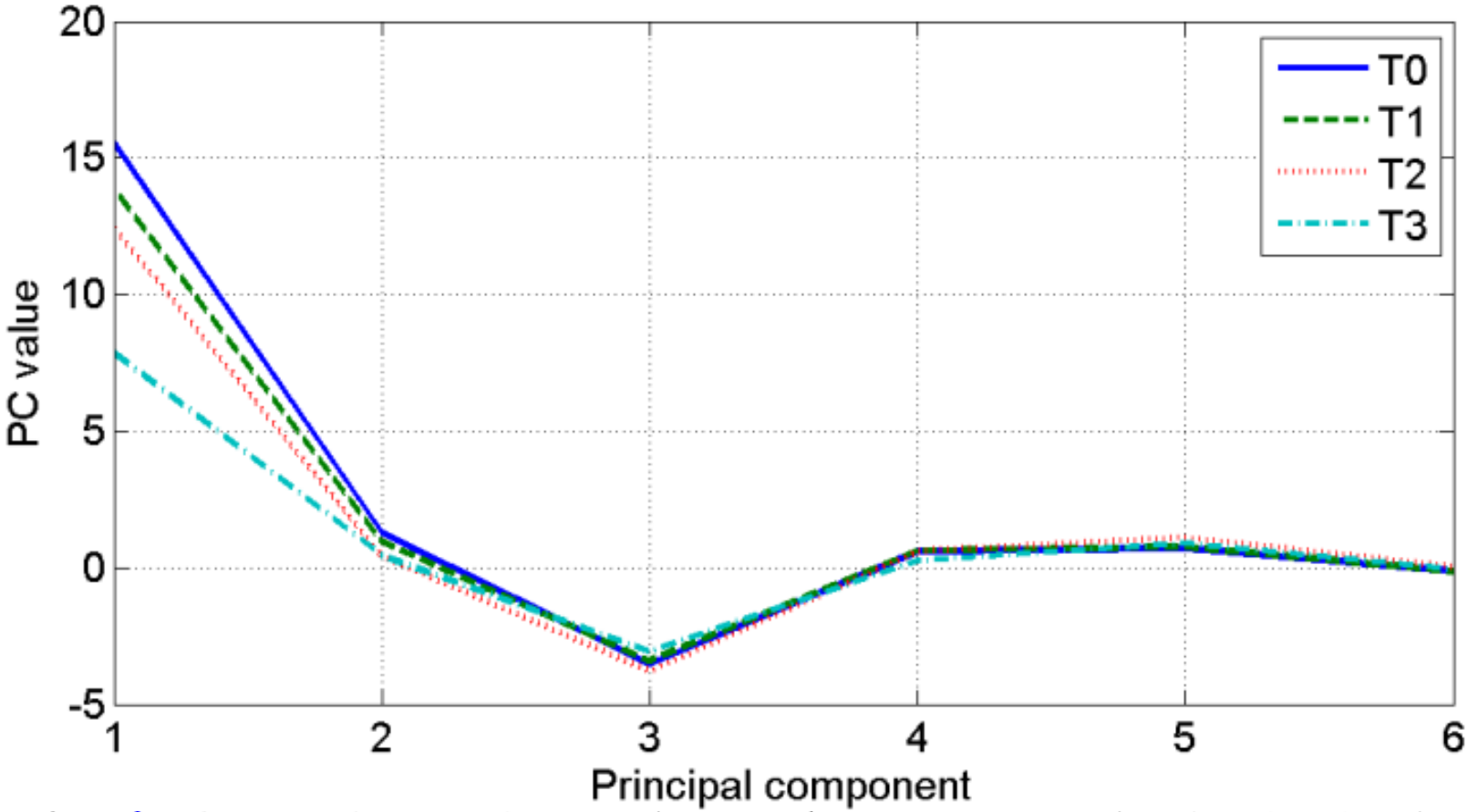
visual and FTIR mapping images

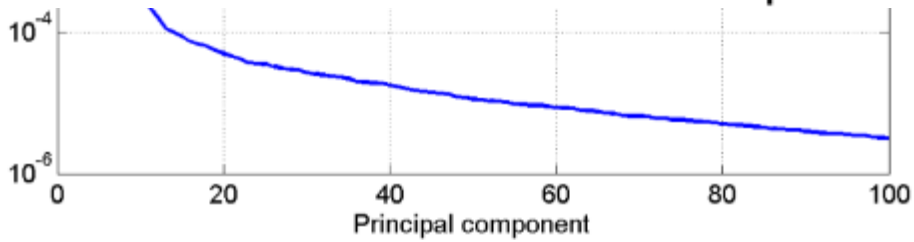
Principal Component Analysis

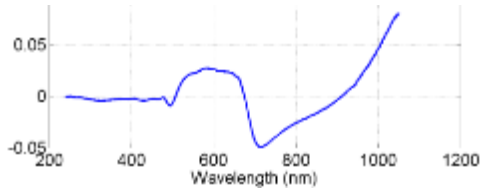
Procedure of PC extraction

1. The mean of each variable from the dataset is subtracted in order to center the data around the origin.
2. The covariance matrix of the data is calculated.
3. The eigenvalues and eigenvectors of the covariance matrix are computed.
4. The orthogonal eigenvectors are normalized to correspond to unit eigenvectors. Now, each of the mutually orthogonal, unit eigenvectors can be interpreted as an axis of the ellipsoid fitted to the data. These eigenvectors are the principal components.
5. The choice of basis transforms the covariance matrix into a diagonal form with the diagonal elements representing the variance of each axis. The proportion of the variance that each eigenvector represents can be calculated by dividing the eigenvalue corresponding to that eigenvector by the sum of all eigenvalues. This variance corresponds to the energy of the principal component.

Principal Component Analysis



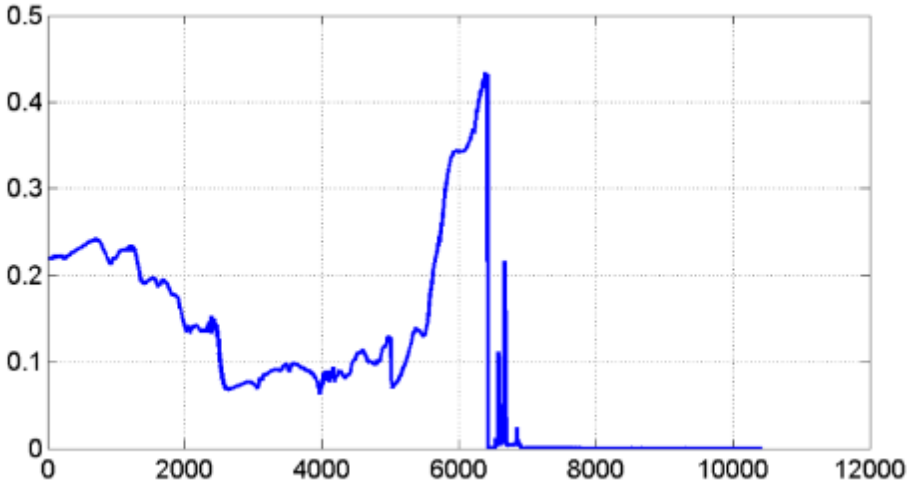




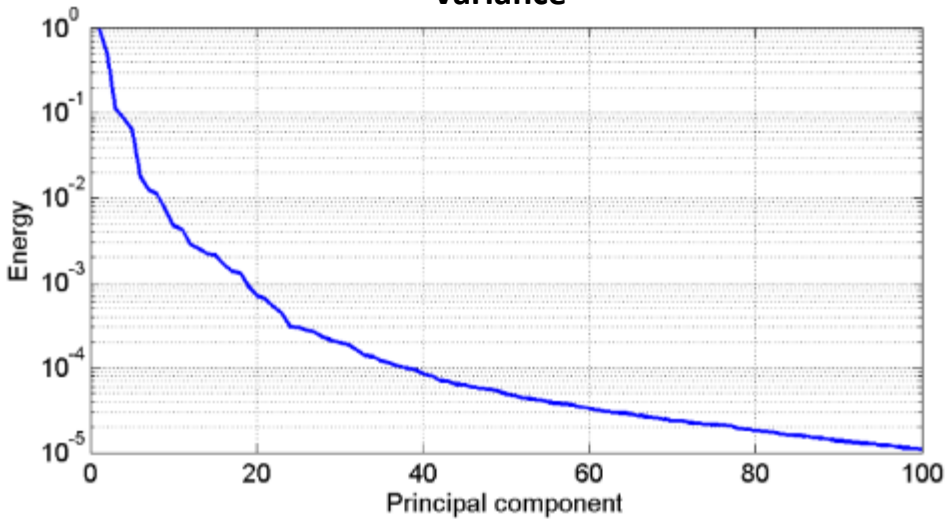
Principal Component Analysis

Fusion of acquired data

Mean-value



Variance



Samples