XXXIII cycle Ph.D. course in Physics
Final year report

Student: Nicola Alchera
Supervisor: Andrea Chincarini

My research field is data analysis applied to medical physics, more in detail I am analyzing PET-amyloid brain images in the context of Alzheimer Disease(AD).

The β-amyloid(Aβ) accumulation in brain tissue is related to the neurodegenerative process that leads to AD. The positron emission tomography (PET) provides us with images which we can use to quantitatively evaluate amyloid burden in brain tissue.

We can evaluate Aβ burden using algorithms called quantification methods (such as ELBA, TDr, SUVr). These methods are able to assess the amyloid load both in whole brain tissue and some specific regions of interest.

It is important to remark that the output provided by the quantification methods, namely the Aβ accumulation, is in general a variable that also depends on the quality of the PET image. The use of different scanners, different acquisition protocols and/or reconstruction algorithms are to be considered problems that limit PET studies (especially multicentric studies) because of the non-comparability of images having different quality.

During my third PhD year I dealt with the problem of image quality assessment and worked to find relationships between PET quality and quantification.

Regarding image quality assessment, I decided to address the problem by defining the quality through measures extracted from the clinical images themselves.
I defined 5 quality measures based on sharpness and noise of images. In defining such measures, I imposed the constraint that they must be as independent as possible from the patient's clinic. I also validated these measures by visual analysis.

Then, using these 5 measures, I clustered PET images in quality-homogeneous subsets, within which the amyloid load quantification was less affected by errors introduced by the difference in quality.

I finally investigated the relations between quality measures and quantification methods: I found that quantification methods based on different algorithms were differently affected by quality. For example, I noticed that ELBA is more stable than SUVr for blurred images, while SUVr is less affected by image noise than ELBA.

I am currently dealing with modeling the relationship between quantification and quality. This could allow to correct quantification values with respect to quality, which is very important because it would reduce errors in statistical studies based on quantification.

Courses attended during PhD

MLCC Summer School Genova, June 17-21 ,MLCC2019 , 3 CFU

Statistic and Probability, Parodi, Passaggio, Kulikovskiy, PhD course 3 CFU
List of given exams during my PhD

Teoria dei Campi, Camillo Imbimbo, Master Degree course, 6 CFU

Summer School of Cosmology, International Center of Theoretical Physics, Trieste 18-29 June 2018, 3 CFU

Very high energy asptrophysics, Fabrizio Tavecchio, Phd course, 3 CFU3

List of published papers during PhD

"Analysis of the Angular Dependence of Time Delay in Gravitational Lensing"; Nicola Alchera, Marco Bonici, Roberta Cardinale, Alba Domi, Nicola Maggiore, Chiara Righi, Silvano Tosi; Symmery 2018,10(7),246, https://doi.org/10.3390/sym10070246

"Towards a New Proposal for the Time Delay in Gravitational Lensing"; Nicola Alchera, Marco Bonici, Nicola Maggiore; Symmetry 2017, 9(10), 202; https://doi.org/10.3390/sym9100202

Conference and Workshops

On 2 February 2020 I had a talk at Aim Kick-off meeting at Pisa University . The title of my talk was "Quality, harmonization and parcellation"

On 30 January 2019 I took part Aim Kick-off meeting at Pisa University

On 13 April 2018 I had a Talk at UniVersum Conference in Bologna. The title of the talk was: Analysis of the Angular Dependence of Time Delay in Gravitational Lensing.