DOCTORAL PROGRAM IN ELECTRICAL AND INFORMATION ENGINEERING

POLITECNICO DI BARI

Development of machine vision algorithms for radiomics

Novel approach to segment tumor tissue and dose for particle therapy

**Cycle XXXVIII**

# PhD candidate

Nicola Ferrara

# Tutors

Filippo Attivissimo

Gabriella Maria Incoronata Pugliese

# Description of the research program

The proposal aims to develop innovative methods for the recognition of medical images in the field of dosimetry and radiomics using Machine Learning algorithms. First aim is to simulate the entirely neutron field of an Accelerated-based BNCT. Then I will study the dose released in the tumor area treated with Boron Neutron Capture Therapy (BNCT). BNCT is a highly selective hadron radiotherapy, based on the 10B(n, α)7Li capture reaction. 10B is deposited in the cancer cell via a drug. Subsequently, the patient is irradiated with thermal neutrons producing an unstable 11B nucleus which decays into an α particle and an excited recoil nucleus of 7Li, which de-excites by emitting 478 keV gamma rays. The reaction has a positive Q-value of 2.78 MeV and the products have high linear energy transfer (LET) which drives the deposition of the emitted energy within a range <10 μm, making it possible to transfer most of the energy into the cell tumor. The starting dataset consists of images simulated with Monte Carlo methods of the dose released in a phantom and detected by a CdZnTe sensor. The images will be analyzed to reconstruct the dose deposition area. This will be made with a tomographic algorithm used for pin-hole SPECT diagnosis. Single Photon Emission Computed Tomography (SPECT) is the method used to detect gamma and reconstruct 3D-images of dose in patient. After successful reconstruction, a Machine Learning (CNN) method will be used for the identification of gamma ray source. This algorithm exploits a CNN network that will be trained and tested on the dosimetric image database. The second phase consists in applying these methods to the analysis of cancer medical images for radiomics purpose, obtaining information on dosimetry and tumors features. I will use existing database of medical images of tumor lesions and I will build a Deep Learning algorithm able to segment images and distinguish lesions from healty tissue. The method will be benchmarked with the most up-to-date medical image recognition methods. During the final part of the project, I will classify tumor images by combining segmentation methods with radiomics extraction methods, in order to extract feature like “energy” and “grey-level”. In this way, a BNCT-SPECT-CT hybrid system could take profit from a full reconstruction method able to measure on-line dose to patient.

## **1.1 Description of the** research activities carried out in the first year

Insert the research activities that you carried out during the academic year, including any period abroad.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Description | Period | Activity abroad |
| Insert title of the first research activity | Simulation of neutron field for BNCT with Geant4  | 1/01-1/09 | NO |
| Insert title of the second research activity | Segmentation of pancreas with CNN model | 1/09-31/12 | NO |

## **1.2 List of the publications written during the academic year**

Insert the list of papers written during the first year. If the paper is still not published indicate its status (e.g., submitted, under review, under 2nd review round, accepted and to appear).

# List of the training and research activities

Specify with the related ECTS the training activities that you carried out in the first years (e.g., courses to attend, conferences, seminars, etc.).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Description | Period | Final exam | ECTS |
| PhD courses (e.g., SCUDO courses) | Numerical methods for Big Data | 1/05-1/06 | NO | 2 |
| Optimal control | 1/02-1/03 | NO | 2 |
| Industry 4.0: optimization, control and security | 1/02-1/03 | NO | 2 |
| English | 1/04-1/05 | YES | 2 |
| Master’s degree courses |  |  |  |  |
|  |  |  |  |
| Participation to seminars and international congresses or workshops | Seminar on software for nuclear, subnuclear and applied physics | 03/0610/06 | YES | 5 |
|  |  |  |  |
| Presentation of research products at international congresses or workshops | Congress of Italian Physics Society | 11/09-16/09 | NO | 7 |
|  |  |  |  |
| 1. TOTAL OF ECTS FOR TRAINING ACTIVITIES
 | 20 |

|  |  |  |  |
| --- | --- | --- | --- |
|  | Description | Period | ECTS |
| Individual research activity | Simulation in Geant4, machine learning algorithm building  | 1 year | 36 |
| Students’ supervision |  |  |  |
| Integrative didactive activities | Lectures on problems in electromagnetism and optic | 1/10-31/12 | 4 |
| Preparation of manuscripts for conferences or journals  |  |  |  |
| 1. TOTAL OF ECTS FOR RESEARCH ACTIVITIES
 | 40 |

|  |  |
| --- | --- |
| 1. TOTAL OF ECTS FOR THE FIRST YEAR (A+B)
 | 60 |
| 1. TOTAL OF ECTS FOR TRAINING ACTIVITIES WITH A FINAL EXAM
 | 7 |

Note that:

* The sum of ECTS for training (A) and research activities (B) for the entire academic year must be 60.
* Of the 180 ECTS required during the 3 years, the PhD student must carry out training activities (A) for a minimum of 36 ECTS and a maximum of 60 ECTS, preferably during the first two years of the course.
* **At least 18 ECTS of the training activities (A) must be obtained by completing the final exam (C).**
* Of the 180 ECTS required during the 3 years, the PhD student must carry out research activities (B) for a minimum of 120 ECTS and a maximum of 144 ECTS.
* Maximum 18 ECTS can be received by graduate schools, Master's degree courses or single-cycle degree courses, provided that the selectable courses are not included in the list of courses attended by the PhD student during his second level training education.
* For all courses attended in Italy and abroad a number of ECTS equal to 50% of the total course ECTS is recognised in case of the final exam is not completed.
* For Politecnico SCUDO courses, the PhD student can receive (without completing the final exam) 50% of ECTS, if a certified attendance of 80% is provided.
* Maximum 12 ECTS can be obtained by courses classified as "soft skills" with the opinion of the Academic Board or the SCUDO Board.
Participation at congresses, workshops and seminars is considered as a didactic activity. ECTS related to each participation is determined by following rules:
	+ 5 hours of seminar (without final exam) = 1.5 ECTS
	+ 1 international congress/workshop day = 1 ECTS
	+ Presentation of a research product at an international congress/
	workshop = 2 ECTS

Examples:

* A 6-ECTS course given in a Master's degree course can be attended by the PhD student who can receive 3 ECTS if he/she does not complete the final exam (in this case the tutor must certify the attendance).
* Attending a 2-ECTS SCUDO course (20-hour of lessons), the PhD student can obtain 1 ECTS, only with the certification of the attendance of the course for at least 16 hours (80%). Otherwise, if the PhD student complete the final exam, 2 ECTS will be obtained and the certification of the attendance is not mandatory.
* If a PhD student attends a 5-day workshop with a contribution, he will obtain 5 ECTS for the participation (if certification of the attendance is presented) + 2 ECTS for the conference contribution.

Please refer to the *Educational regulations of the Doctoral School of Politecnico di Bari*: http://www.poliba.it/sites/default/files/dottorati/regscudopoliba.pdf

Insert PhD student name

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Insert Tutor 1 name

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Insert Tutor 2 name

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