Holy Spirit University of Kaslik
Doctoral College
Doctoral Studies Rules and Regulations/ Article 2

PhD Thesis Proposal (PTP)[1]

General Information		
PhD Thesis Title	***Topology and machine learning for biomedical and vegetal images and time series analysis.***	
USEK Doctoral Program	(Mathematics Field - Cas d'une codirection)	
Joint Guardianship/Cotutelle	x Yes	Partnership university's doctoral program: **To be established within the appropriate time framework**
	☐ No	
Research Center	CReSTIC (URCA)/Math Department (USEK)	
Research Group	NA	
Research Axis	- Health Sciences and Technologies - Artificial Intelligence (AI & Dynamic Data Analysis).	
PhD Supervisor	Name & Title: Mohammad Kacim/Associate Professor Email: mohamadkacim@usek.edu.lb	University Address: Holy Spirit University of Kaslik - USEK
Co-supervisor (if applicable)	Name & Title: Alban Goupil/HDR Email: alban.goupil@univ-reims.fr	University Address: University of Reims Champagne-Ardennes
Location (s)	Location 1: USEK	Work shift calendar /per year (%): 65%
	Location 2: University of Reims Champagne -Ardenne	Work shift calendar /per year (%): 35%
Potential funding and scholarship	**To be established within the appropriate time framework**	

Applicant's Name and Profile	MS in Mathematics or equivalent.
Comps Exam Language	x Oral Assessment ☐ Written Assessment ☐ Arabic x French x English

Subject's national or worldwide context, objectives & research lines
The main objective is to achieve a technique to improve the detection or diagnosis of diseases in images, biomedical, plant or other, and to classify these diseases. Machine learning models have achieved tremendous success in image analysis. However, their application to complex, high-dimensional systems has been significantly hampered by relevant feature representations. Geometric analysis features can characterize local structure information very well but tend to be inundated with detail and will lead to data

[1] The PhD Thesis Proposal should not exceed three pages. It shall be approved by the School/Faculty.

complexity. Topological data analysis (TDA) is an active area of data science with growing interest and notable successes in a number of applications, including image analysis. TDA brings a different perspective: more structural analysis than analytical. It extracts a large set of topological features from high-dimensional datasets, which provides a different perspective for machine learning. The proposal of a rapid, robust and economical estimation tool, without the use of substances and additional chemicals, based solely on images and mathematical and data science techniques could enable health officials optimize the planning of resource strategies. For example, it helps in the detection of cancer, prostate, brain cancers or others, COVID-19 variants in images. This subject should also allow to bring additional tools in the application field of smart agriculture in the detection of symptoms of "Flavescence Dorée" in the Champagne vineyard from color or multispectral images. The development of robust algorithms for the detection of this disease, capable in the long term of being embarked for prospecting the 34,000 ha of AOC Champagne, will make it possible to respond to a serious and pandemic problem which is causing the withering of vines with important and radical consequences. Noting that this methodology will not only be applied on fixed images but also on time series images which allow a better detection and classification of the progress of diseases in vegetal images.

Outcomes (OCs): What do we wish to achieve?	
OC1:	Combination between machine and topological data analysis tools
OC2:	Detection of cancer or virus in biomedical images
OC3:	Detection of diseases symptoms in vegetal images

References (R) (5 most recent peer-reviewed publications in the field)	
R1:	A. Rammal, R. Assaf, A. Goupil, M. Kacim, V. Vrabie, Machine Learning Techniques on Homological Persistence Features for Prostate Cancer Diagnosis, Bioinformatics, October 2022.
R2:	R. Assaf, A. Goupil, M. Kacim, V. Vrabie, 2D+t track detection via relative persistent homology, International Journal of Imaging Systems and Technology, June 2021.
R3:	R. Assaf, A. Goupil, V. Vrabie, T. Boudier, M. Kacim, Persistent homology for object segmentation in multidimensional grayscale images, Pattern recognition letters, 2018, ISSN 0167-8655.