ESA Contract Nr 4000130990/20/NL/SC

ESA-LU Course: Introduction to Wavelets for Space Applications

Project cost: 24,579 € EUR
Project duration: 2020. July -2021. February

Lessons + Examples + OnLine with *PyWavelets Hands-On Scripts*

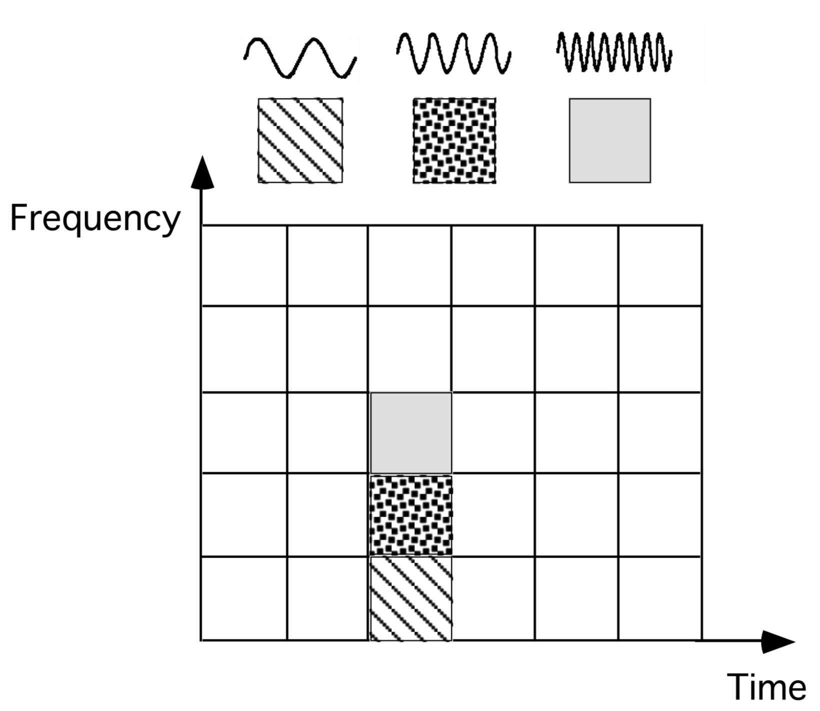
The **objective** of the activity is to develop and implement university-level, educational, accredited, in-class and online, available internationally, **wavelet digital signal processing (DSP) lessons for Space Applications**.

Introduction and Scope. Wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale. They have advantages over traditional Fourier methods in analyzing physical situations where the signal contains discontinuities and sharp spikes. Wavelets were developed independently in the fields of mathematics, quantum physics, electrical engineering, and seismic geology in the 1980s. Their use was quickly adopted by engineers who desired a method to meet the challenge of identifying frequencies in time series without sacrificing position. Interchanges between these fields led to an initial abundance of wavelet applications such as image compression, turbulence, human vision, radar, and earthquake prediction.

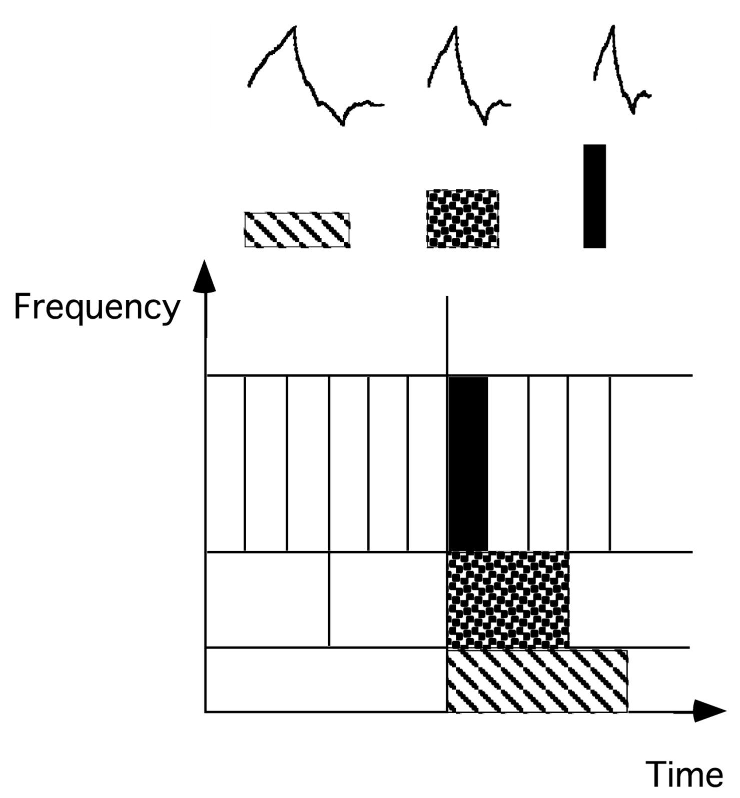
After a generation of use, the applications for wavelets have grown more sophisticated to reach the fields of data mining and artificial intelligence, while new, interested users continue to enter the Digital Signal Processing scene. We have an opportunity to bridge the gap between new, interested users and those working at the cutting edge of digital signal processing. **Space applications provides such a bridge**.

[A. Graps (1995). An Introduction to Wavelets. IEEE Computational Science and Engineering, Summer 1995, vol. 2, num. 2, published by the IEEE Computer Society, 10662 Los Vaqueros Circle, Los Alamitos, CA 90720, USA,]

Fourier: A single window is used for all frequencies



Wavelets: The windows vary for different frequencies



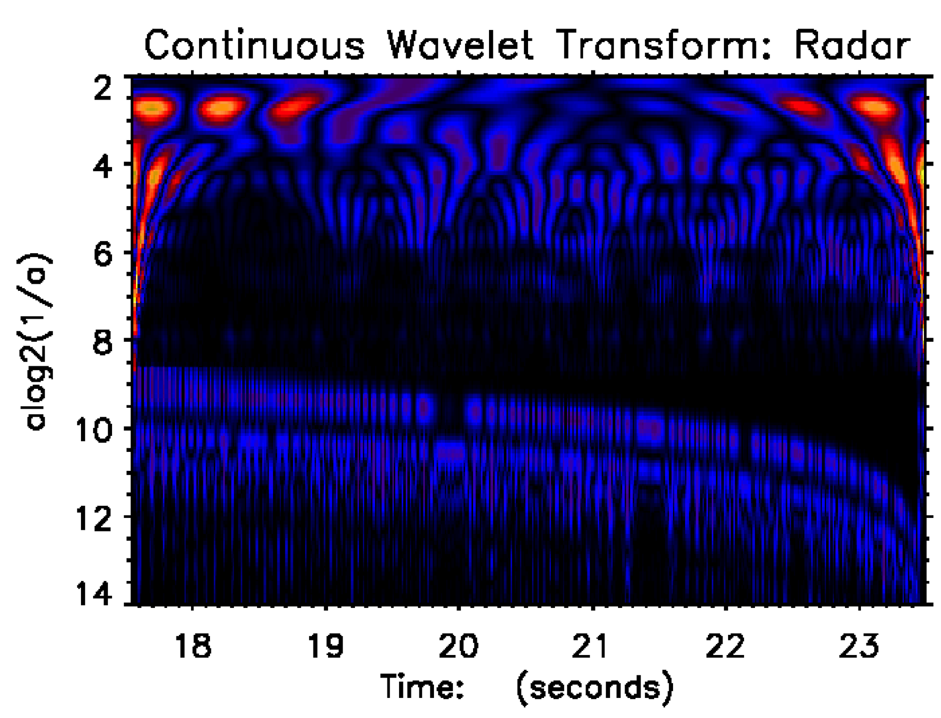
Course Topics:

I. What Are Wavelets?
II. Fundamental Ideas. Wavelet Zoom
III. Continuous Wavelet Transform Step by Step
IV. Discrete Wavelet Transform Step by Step
V. Wavelet Bases
VI. Introduction to Wavelet Analysis
VII. Edge Detection and Image Reconstruction
VIII. Denoising
IX. Compression: Wavelet Transform Compression,
Wavelet Packet Compression
X. Wavelets and A.I.
XI Reproducible Research
XII Miscellaneous Wavelet Transforms I
XIII Miscellaneous Wavelet Tranforms II

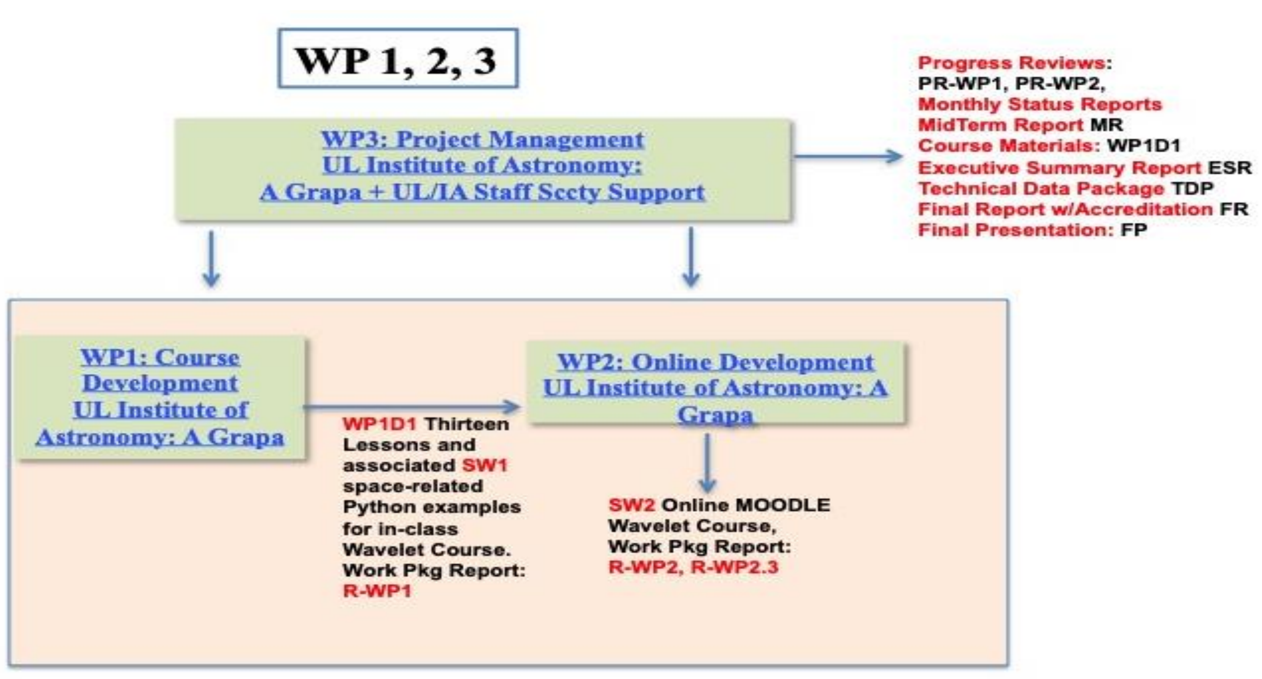
Wavelets used in todays State of the Art Space Applications:

Data lossless compression / Satellite image data downlinks
Artificial Intelligence / Neural Network Training / Autonomous Spacecraft Navigation
Data Mining: Clustering, Classification
Image Enhancement /Google Maps filters
Noise Reduction / Optical Communication / LIDAR Signals / SAR interferograms
Multidirectional Fringe Analysis
Anthropogenic Interference Mitigation / Scintillation Detection
DeModulation of Satellite Signals
Fault Detection / Satellite navigation system stability
Pattern Matching / Characterising Atmospheric Turbulence
Multispectral Satellite Image Fusion
Digital Wireless Communication (IoT) / Multicarrier CDMA

Huygens Probe Radar: Sound->Time Series during descent



Project Work Packages



Wavelets can move the Latvian DSP community up the tech value chain

Practical Space educational Initiatives, such as this ***Wavelet Applications Courses for Space Applications*** add creative Space value to the country's existing technological base. The wavelet transforms presented in the Course are used in many technological industries. It would meet policy makers' evaluation that Latvia "must move up the value chain ladder" and show Space linkages to the Latvian tech industry, especially if the educational information were available outside of the university in an online course. Linkages to the tech Industry are important conduits of the Triple Helix concept to drive innovation.