Requirements for LTFAT

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Contents

Chapter 1

Requirements for LTFAT

These are the top-level requirements for LTFAT.

1.1 LTFAT master requirement

Description: *LTFAT* **must** be usable.
Rationale: The world needs a good time-frequency toolbox.
Solved by: 1.2.1 Available, 1.2.2 Fast, 1.2.3 Free as in speech, 1.2.4 Gratis / Free as in beer, 1.2.5 Purpose, 1.2.6 Usable
Status: finished

1.2 Fundamental properties

These are the fundamental properties and values of LTFAT.

1.2.1 Available

Description: *LTFAT* **must** be available
Rationale: LTFAT must be available for the users on the platforms they work on.
Depends on: 1.1 LTFAT master requirement
Solved by: 1.4.2 Homepage, 1.8.8 Platform Support
Status: finished

1.2.2 Fast

Description: *LTFAT* **must** be fast.
Rationale: If it is not fast, it will not be used.
Depends on: 1.1 LTFAT master requirement
Solved by: 1.7.1 Backend
Status: finished

1.2.3 Free as in speech

Description: *LTFAT* **must** free as in speech.
Rationale: LTFAT should be used to benefit other free and open source software projects
Depends on: 1.1 LTFAT master requirement
Solved by: 1.4.1 GNU Public Licence
Status: finished

1.2.4 Gratis / Free as in beer

Description: *LTFAT* **must** be available for free.
Rationale: Good mathematics software must be available for people that cannot pay any amount of money for the software.
Depends on: 1.1 LTFAT master requirement
Solved by: 1.4.1 GNU Public Licence, 1.8.1 Octave, 1.8.5 Octave
Status: finished

1.2.5 Purpose

Description: *LTFAT* **must** have a relevant purpose.
Rationale: A purpose is the thing to have
Depends on: 1.1 LTFAT master requirement
Solved by: 1.6.1 Academic, 1.5.13 Selected Topics
Status: finished

1.2.6 Usable

Description: The user must be able to use *LTFAT*
Rationale: The user must be able to use *LTFAT*
Depends on: 1.1 LTFAT master requirement
Solved by: 1.3.7 User friendly, 1.7.5 Working
Status: finished

1.3 User Friendly

User friendly

1.3.1 Demos

Description: *LTFAT* **must** include demos
Rationale: Demos (demonstrationg scripts) gives the user a quick way to get started on a topic
Depends on: 1.3.7 User friendly
Solved by: 1.5.1 Auditory functions, 1.5.8 Test signals, 1.5.9 Signal processing utilitites
Status: finished

1.3.2 Design Specification

Description: *LTFAT* **must** have a design specification
Rationale: A design specification ensures a uniform user interface
Depends on: 1.3.7 User friendly
Status: finished

1.3.3 Documented

Description: The *LTFAT* **must** be well documented
Rationale: People need good documentation because the toolbox is complicated to understand
Depends on: 1.3.7 User friendly
Solved by: 1.9.5 Mat2doc
Status: finished

1.3.4 Graphical User Interface

Description: *LTFAT* **must** have a simple GUI
Rationale: There must be an easy way for new users to get started
Depends on: 1.3.7 User friendly
Solved by: 1.9.3 GPC
Status: finished

1.3.5 Parameter handling

Description: *LTFAT* **must** handle parameters in a userfriendly way
Rationale: Learning and working with the toolbox is much easier if there is a standardized and user friendly way of working with optional parameters. This is solved by the ltfatarghelper function in Matlab and Octave
Depends on: 1.3.7 User friendly
Status: finished

1.3.6 Tutorial

Description: *LTFAT* **must** have a tutorial
Rationale: There must be an easy way for new users to get started
Depends on: 1.3.7 User friendly
Status: finished

1.3.7 User friendly

Description: *LTFAT* **must** be user friendly.
Rationale: If it is not user friendly, it will not be used.
Depends on: 1.2.6 Usable
Solved by: 1.3.1 Demos, 1.3.2 Design Specification, 1.3.3 Documented, 1.3.4 Graphical User Interface, 1.3.5 Parameter handling, 1.3.6 Tutorial
Status: finished

1.4   Open Source

These requirements covers why and how LTFAT is open source

1.4.1   GNU Public Licence

Description: *LTFAT* **must** be licenced under the GNU Public License
Rationale: Good reasons are listed here https://www.gnu.org/licenses/why-not-lgpl.html. Octave and FFTW are also GPL.
Depends on: 1.9.2 FFTW, 1.2.3 Free as in speech, 1.2.4 Gratis / Free as in beer, 1.8.5 Octave
Status: finished

1.4.2   Homepage

Description: The *LTFAT* **must** have a homepage
Rationale: It must be possible to find everything about LTFAT from one homepage (or at least links from there)
Depends on: 1.2.1 Available
Solved by: 1.9.5 Mat2doc, 1.4.3 Sourceforge
Status: finished

1.4.3   Sourceforge

Description: The *homepage* **must** use Sourceforge
Rationale: The development and download part of the homepage should be available on a publically accesible server
Depends on: 1.4.2 Homepage
Status: finished

1.5   Specific functionality

These requirements specify areas of functionality/topics that LTFAT must cover

1.5.1   Auditory functions

Description: *LTFAT* **must** include basic auditory functions
Rationale: LTFAT should cover a limited subset of very basic auditory models to be able to create Erb-scale filterbanks etc.
Depends on: 1.3.1 Demos, 1.6.7 Paper about the Erblet-transform
Status: finished

1.5.2   Filterbanks

Description: *LTFAT* **must** include a filterbank section
Rationale: Filterbanks are a useful when Gabor or Wavelet analysis are not sufficient, and the creating of good filterbanks is far from trivial. LTFAT must include easy to use functions to create dual and tight filterbanks, and methods for easy creating of filters that are correctly spaced and weighted.
Depends on: 1.5.13 Selected Topics
Status: finished

1.5.3 Fourier analysis

Description: *LTFAT* **must** include Fourier analysis
Rationale: LTFAT should cover a subset of Fourier analysis:
Depends on: 1.5.13 Selected Topics
Solved by: 1.5.10 Spectral Analysis
Status: finished

1.5.4 Frame analysis

Description: *LTFAT* **must** include a frame analysis framework
Rationale: An object-oriented framework implementing frames will make it easy for the user to try out different frames in an application, and it will make it easier for LTFAT developers to formulate high-level algorithms that work for all (or just some) frames.
Depends on: 1.5.13 Selected Topics
Status: finished

1.5.5 Gabor analysis

Description: *LTFAT* **must** include Gabor analysis
Rationale: LTFAT should cover a subset of Gabor analysis:
Depends on: 1.5.13 Selected Topics
Solved by: 1.5.12 Totally Positive functions
Status: finished

1.5.6 Non-stationary Gabor frames

Description: *LTFAT* **must** non-stationary Gabor frames
Rationale: Non-stationary Gabor frames are the generalization of Gabor frames to non-equidistant time steps. LTFAT must include them to support recent research and to make it possible to mature the field of signal processing in this area, as the details of the construction are far from trivial. LTFAT must include easy to use functions to create dual and tight non-stationery Gabor frames, and methods for easy creating of filters that are correctly spaced and weighted.
Depends on: 1.6.4 Paper about nonstationary Gabor systems, 1.5.13 Selected Topics
Status: finished

1.5.7 Quadratic distributions

Description: *LTFAT* **must** contain quadratic distributions
Rationale: LTFAT should cover a subset of quadratic distributions. Candidates could be:

- The Wigner distribution

- The Choi-Williams distribution

Different versions of the distributions should be created depending on if they are considered in the purely finite, discrete case, or if they are thought of as approximations of the continuous case. Even though quadratic distributions are rarely used in application, they are imporant instruments for teaching and visualizations.
Depends on: 1.5.13 Selected Topics
Status: not done

1.5.8 Test signals

Description: *LTFAT* **must** include a limited set of test signals
Rationale: LTFAT should include a small subset of test signals to make it possible to write interesting demos and examples
Depends on: 1.3.1 Demos
Status: finished

1.5.9 Signal processing utilitites

Description: *LTFAT* **must** include a limited set of signal processing functions
Rationale: LTFAT should include a small subset of signal manipulation functions to make it possible to write demos and examples without loosing the focus of the demo.
Depends on: 1.3.1 Demos
Status: finished

1.5.10 Spectral Analysis

Description: *LTFAT* **must** contain function for classical spectral analysis
Rationale: It should be possible to use LTFAT to perform an easy spectral analysis of a signal by looking at its spectrum, power (or energy) spectral density functions etc. Several classes of input signals should be supported, both finite, discrete signals and also sampled signals embedded in the finite, discrete seeting.
Depends on: 1.5.3 Fourier analysis
Status: not done

1.5.11 Streaming framework

Description: *LTFAT* **must** include a streaming framework
Rationale: An simple set of methods using the frames framework and interfacing to the sound processing capabilities of the underlying system in a platform independent way will make it much simpler for students and researchers to experiment with streaming algorithms.
Depends on: 1.5.13 Selected Topics
Status: finished

1.5.12 Totally Positive functions

Description: *LTFAT* **must** totally positive window functions
Rationale: It should be possible to create suitable totally positive FIR windows and their dual windows to be used for Gabor analysis
Depends on: 1.5.5 Gabor analysis
Status: not done

1.5.13 Selected Topics

Description: *LTFAT* **must** cover selected topics
Rationale: LTFAT should cover certain topics
Depends on: 1.2.5 Purpose

Solved by: 1.5.2 Filterbanks, 1.5.3 Fourier analysis, 1.5.4 Frame analysis, 1.5.5 Gabor analysis, 1.5.6 Non-stationary Gabor frames, 1.5.7 Quadratic distributions, 1.5.11 Streaming framework, 1.5.14 Wavelet analysis
Status: finished

1.5.14   Wavelet analysis

Description: *LTFAT* **must** include Wavelet analysis
Rationale: LTFAT should cover a subset of Wavelet analysis:
Depends on: 1.5.13 Selected Topics
Solved by: 1.5.15 YAWTB
Status: finished

1.5.15   YAWTB

Description: *LTFAT* **must** include selected function from YAWTB
Rationale: It has been agreed to merge selected parts of YAWTB into LTFAT
Depends on: 1.5.14 Wavelet analysis
Status: not done

1.6   Academic requirements

These are the academic requirements for LTFAT.

1.6.1   Academic

Description: *LTFAT* **must** support selected papers
Rationale: Major parts of the software from these papers should be integrated into *LTFAT*, or *LTFAT* should contain functionality to support the software from these papers.
Depends on: 1.2.5 Purpose
Solved by: 1.6.3 LTFAT 1.0 paper, 1.6.4 Paper about nonstationary Gabor systems, 1.6.5 Paper about non-separable lattices, 1.6.6 Ph.d. thesis of Z. Prusa, 1.6.7 Paper about the Erblet-transform, 1.6.8 Paper about the Erblet-transform, 1.6.9 LTFAT 2.0 book chapter, 1.6.10 Paper about the generalized Goertzel transform
Status: finished

1.6.2   Paper about factorization algorithms

Description: *LTFAT* **must** contain the algorithms in ltfatnote011
Rationale: LTFAT must containg the factorization algorithm for the DGT from "Efficient Algorithms for the Discrete Gabor Transform with a Long FIR Window" by Soendergaard
Depends on: 1.6.3 LTFAT 1.0 paper
Solved by: 1.7.4 Reliable timings
Status: finished

1.6.3 LTFAT 1.0 paper

Description: *LTFAT* **must** contain the functionality from Ltfatnote015
Rationale: LTFAT must containg all the functionality mentioned in the LTFAT 1.0 paper:
"The Linear Time Frequency Analysis Toolbox" by Soendergaard, Torresani and Balazs.
Depends on: 1.6.1 Academic
Solved by: 1.6.2 Paper about factorization algorithms
Status: finished

1.6.4 Paper about nonstationary Gabor systems

Description: *LTFAT* **must** contain the algorithms in ltfatnote018
Rationale: LTFAT must contain the algorithms about non-stationary Gabor systems from the
paper "Nonstationary Gabor frames"
Depends on: 1.6.1 Academic
Solved by: 1.5.6 Non-stationary Gabor frames
Status: finished

1.6.5 Paper about non-separable lattices

Description: *LTFAT* **must** contain the algorithms in ltfatnote019
Rationale: LTFAT must contain the algorithms about non-separable lattices from the paper
"Efficient algorithms for discrete Gabor transforms on a nonseparable lattice".
Depends on: 1.6.1 Academic
Solved by: 1.7.4 Reliable timings
Status: finished

1.6.6 Ph.d. thesis of Z. Prusa

Description: *LTFAT* **must** contain the algorithms in ltfatnote026
Rationale: LTFAT must contain the segmented Wavelet transform.
Depends on: 1.6.1 Academic
Status: finished

1.6.7 Paper about the Erblet-transform

Description: *LTFAT* **must** contain the algorithms in ltfatnote027
Rationale: LTFAT must contain the algorithms about the Erblet-transform from the paper
"The ERBlet transform: An auditory-based time-frequency representation with perfect recon-
struction"
Depends on: 1.6.1 Academic
Solved by: 1.5.1 Auditory functions
Status: finished

1.6.8 Paper about the Erblet-transform

Description: *LTFAT* **must** contain the algorithms in ltfatnote029
Rationale: LTFAT must contain the algorithms about the Gabor dual windows by convex
optimization from the paper "Designing Gabor windows using convex optimization"
Depends on: 1.6.1 Academic

Status: finished

1.6.9   LTFAT 2.0 book chapter

Description: *LTFAT* **must** contain the functionality from Ltfatnote030
Rationale: LTFAT must containg all the functionality mentioned in the LTFAT 2.0 book chapter: "The Large Time Frequency Analysis Toolbox 2.0" by Prusa, Soendergaard, Holighaus, Wiesmeyr and Balazs.
Depends on: 1.6.1 Academic
Status: finished

1.6.10   Paper about the generalized Goertzel transform

Description: *LTFAT* **must** contain the algorithms in Syra2012goertzel
Rationale: LTFAT must contain the algorithms about the generalized Goertzel transform from the paper "Goertzel algorithm generalized to non-integer multiples of fundamental frequency" by P. Sysel and P. Rajmic.
Depends on: 1.6.1 Academic
Status: finished

1.7   Infrastructure

These requirements cover the infrastructure needed to develop, host and distribute LTFAT

1.7.1   Backend

Description: *LTFAT* **must** be upon a backend in C or C++.
Rationale: If it is not fast, it will not be used.
Depends on: 1.2.2 Fast, 1.7.4 Reliable timings
Solved by: 1.9.2 FFTW, 1.9.4 Lapack, 1.9.6 Portaudio
Status: finished

1.7.2   Testing Robot

Description: *LTFAT* **must** have a testing robot
Rationale: A automated system that runs the test suite on all the supported platforms saves a lot of very tedious work.
Depends on: 1.7.5 Working
Status: not done

1.7.3   Testing Suite

Description: *LTFAT* **must** have a testing suite
Rationale: A testing suite that covers all functions helps find bugs, regressions and makes it easier to port to new architectures.
Depends on: 1.7.5 Working
Status: finished

1.7.4 Reliable timings

Description: *Selected algorithms* **must** be accurately timeable.
Rationale: Certain papers make statements about the speed of algorithms included in LTFAT. There must be a timing framework to accurately time these algorithms
Depends on: 1.6.2 Paper about factorization algorithms, 1.6.5 Paper about non-separable lattices
Solved by: 1.7.1 Backend
Status: finished

1.7.5 Working

Description: *LTFAT* **must** work.
Rationale: It is useless if it does not work.
Depends on: 1.2.6 Usable
Solved by: 1.7.2 Testing Robot, 1.7.3 Testing Suite
Status: finished

1.8 Platforms requirements

These are the supported platforms that LTFAT must always work on

1.8.1 Octave

Description: *LTFAT* **must** work on Linux
Rationale: LTFAT must work on Linux because it is the most used, free operating system.
Depends on: 1.2.4 Gratis / Free as in beer, 1.8.8 Platform Support
Status: finished

1.8.2 Mac

Description: *LTFAT* **must** work on Mac
Rationale: LTFAT must work on Mac because this operating system is used by many researchers on their laptops
Depends on: 1.8.8 Platform Support
Status: finished

1.8.3 Matlab

Description: *LTFAT* **must** work in Matlab
Rationale: Many people use Matlab and it is generally faster than Octave
Depends on: 1.8.8 Platform Support
Solved by: 1.8.4 Matlab oldest version
Status: finished

1.8.4 Matlab oldest version

Description: *LTFAT* **must** work in Matlab 2009b
Rationale: This is the oldest version we support. Older versions wil not work because we use is output parameters
Depends on: 1.8.3 Matlab
Status: finished

1.8.5 Octave

Description: *LTFAT* **must** work in Octave
Rationale: Many people cannot afford a commercial software solution. We should support the growth of Octave by expanding the software available for Octave.
Depends on: 1.2.4 Gratis / Free as in beer, 1.8.8 Platform Support
Solved by: 1.4.1 GNU Public Licence, 1.8.6 Octave oldest version, 1.8.7 Octave newest version
Status: finished

1.8.6 Octave oldest version

Description: *LTFAT* **must** work in Octave 3.6
Rationale: This is the oldest Octave version we support. Older versions wil not work because we use the tilde symbol in output parameters.
Depends on: 1.8.5 Octave
Status: finished

1.8.7 Octave newest version

Description: *LTFAT* **must** work in Octave 3.8
Rationale: This is the current stable Octave version
Depends on: 1.8.5 Octave
Status: finished

1.8.8 Platform Support

Description: *LTFAT* **must** support common computing platforms
Rationale: LTFAT must be available for the users on the platforms they work on.
Depends on: 1.2.1 Available
Solved by: 1.8.1 Octave, 1.8.2 Mac, 1.8.3 Matlab, 1.8.5 Octave, 1.8.9 Python, 1.8.10 Windows
Status: finished

1.8.9 Python

Description: *LTFAT* **must** work in Python
Rationale: Python is the next big thing in numerical computations
Depends on: 1.8.8 Platform Support
Status: not done

1.8.10 Windows

Description: *LTFAT* **must** work on Windows
Rationale: LTFAT must work on Windows because it is the most used operating system.
Depends on: 1.8.8 Platform Support
Status: finished

1.9 Software used by LTFAT

These are the software requirements of LTFAT.

1.9.1 BLAS

Description: *LAPACK* **requires** *BLAS*
Rationale: BLAS is a requirement for LAPACK
Depends on: 1.9.4 Lapack
Status: finished

1.9.2 FFTW

Description: The *backend* **must** use *FFTW*
Rationale: FFTW is the fastest, open source, cross-platform FFT library available.
Depends on: 1.7.1 Backend
Solved by: 1.4.1 GNU Public Licence
Status: finished

1.9.3 GPC

Description: The *GUI* **must** use *GPC*
Rationale: GPC (General Polygon Clipper) is an open-source (but not GPL) that can compute set interesection etc. It is used by the GUI
Depends on: 1.3.4 Graphical User Interface
Status: finished

1.9.4 Lapack

Description: The *backend* **must** use *LAPACK*
Rationale: LAPACK is the fastest, open source, cross-platform linear algebra available.
Depends on: 1.7.1 Backend
Solved by: 1.9.1 BLAS
Status: finished

1.9.5 Mat2doc

Description: The *LTFAT* **must** use *mat2doc*
Rationale: mat2doc creates beautiful documentation
Depends on: 1.3.3 Documented, 1.4.2 Homepage
Status: finished

1.9.6 Portaudio

Description: The *backend* **must** use *Portaudio*
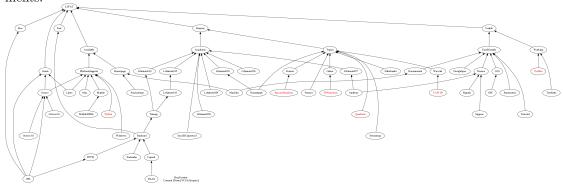**Rationale:** Portaudio is the best cross-platform, open-source audio library available.
Depends on: 1.7.1 Backend
Status: finished

Chapter 2

Graphical overview

2.1 Figure 1

The following figure shows a graphical overview of the relationships between the LTFAT requirements.

2.2 Figure 2 - grouped

This following figure shows the LTFAT requirements grouped by topics. The graph is identical to the one on Figure 1, only the layout is different.