Abstract—RA T (Radar Tools) is a small collection of tools for advanced image processing of SAR remote sensing data, originally started as a student's project and currently under further development at the Department of Computer Vision and Remote Sensing of the Technical University of Berlin. It is programmed in IDL (Interactive Data Language) and uses IDL widgets as graphical user interface. Current features include for example speckle filters, polarimetric basis transforms and decompositions, as well as some interferometric routines like coherence calculation and interferogram filtering.

RA T runs on various operating systems and is available free of charge on the web. The purpose of this paper is to give an overview of the current development status of RA T, and, in this way, to increase its recognition in the scientific community.

I. INTRODUCTION

In recent years, the usage of synthetic aperture radar (SAR) data became more and more popular and is used in many scientific fields. Several new and promising algorithms are described in literature. However, remote sensing software like Erdas Image or ENVI include only some basic and very well-established SAR functionality. Advanced algorithms often have to be implemented by oneself, with the consequence that in many cases they’re almost exclusively used by their respective developer.

The main motivation for RA T is to offer some kind of experimental platform for advanced SAR image processing. This is achieved by providing a software with basic SAR data handling functionality, like data import and export, as well SAR specific preprocessing and display functions. The programming interface of RA T is kept simple and adding new functionality is quite easy. Function templates and a step-by-step description of how to program a RA T module is included in the distribution. In this way, everybody who is interested might use RA T as framework for his own, possibly experimental, developments. In addition, RA T can be used to better promote own algorithms to the public. Even smaller developments, made for example in the frame of diploma thesis, can be implemented as a RA T module and easily distributed to a wider audience.

The second motivation of this software package is a better distribution of modern SAR algorithms to the base of non-expert users. Application oriented research laboratories are in many cases dependent on the limited offerings of commercial software packages. Additionally, complex multidimensional SAR data is often found to be hard to handle by non-SAR-experts. RA T tries to simplify the handling of such data by simple menu-driven functions and a visual feedback of all functions on the screen. This should allow also non-experts to benefit from RA T and from SAR data in general.

RA T can be downloaded and used free of charge [1]. Additionally, RA T is open-source software. This means that its complete source-code is available to everybody who is interested. The source code can be modified, corrected and even used for other projects (for details please read license). However, it is important to note that RA T is not a professional development. It is generally seen as an experimental project, so there will be always bugs and wrong or not working modules, and no guarantee can be given for any of its functions.

II. CONCEPT

RA T is programmed entirely in IDL (Interactive Data Language). A direct consequence of programming in IDL is that RA T is a cross-platform application. It can be used under all operating systems supported by IDL. Programming in IDL is generally simple and implementing new routines can be performed quickly, even by non-expert programmers. Since the availability of the IDL Virtual Machine [2], running RA T does not require any commercial software license. Only for development of new routines, the commercial full license of IDL is required.

Of course, the usage of IDL has the drawback of partly slow execution speed. It was tried to circumvent this effect by using IDL-specific programming optimizations in many routines. Often, the difference in execution speed of RA T, compared to a pure C program, is not significant.

The concept of RA T is to provide a generic SAR image handling platform, which is easy to understand and to extend by own functions. Basically, RA T is based on optimized display routines for many typical SAR data representations, like for example complex SAR images, polarimetric SAR images with several layers, or interferometric image pairs. If an arbitrary image is loaded, its data representation is recognized using file header information, or has to be set interactively. Once knowing the type of SAR data, a preview in screen
resolution is calculated and displayed automatically in an optimized way.

If an image processing function is called, RAT performs all calculations on the original, full-resolution data set. Once finished, again a preview at screen-resolution is calculated from the processed data. If the image processing step changed the data representation, the corresponding optimized display routine will be selected automatically. This procedure has the advantage that even unexperienced users immediately get visual feedback of the performed image operations. The emphasis of RAT lies in preserving the maximum possible image quality, when performing the image processing in full-resolution as well as when calculating the screen preview.

RAT has a modular design which can easily be understood and extended by own functions. As programming in IDL is generally simple, implementing new routines can be performed quickly, even by non-expert programmers. Commented function templates are included in the source distribution, which contain all the code relevant for adding own functionality. Basically, any image transform can be performed almost independently from the main program, as long as after the image operation the new image parameters for the preview calculation are set correctly. More complex modules, which require also changes in the main program, are of course also possible, as the complete source code of RAT is available.

Finally, it has to be mentioned that RAT uses vertical tiling in most of its routines, which drastically reduces its memory consumption. Consequently, there is no limit on the image size to be processed. The vertical tiling is implemented in two versions, one for algorithms which don’t require block overlap, and one using block overlap. Thereby, the procedure of block handling is kept separated from the respective processing algorithm. In this way, new functions can be implemented without having to think about block processing.

III. FEATURES

A. Generic

RAT is not intended to become a fully-featured image processing software. Therefore, only a basic set of generic image manipulating functions is provided. Up to know, images can be mirrored horizontally and vertically as well as changed in their size. Additionally, subsets can be cut out of a full scene and areas of interest can be displayed magnified on the screen. Currently it is not planned to implement significantly more functionality in the direction of image handling, as this would only over-complicate the program design, data formats and execution times. For advanced image handling, standard remote sensing software can be used subsequent to the data processing in RAT.

RAT uses an own simple data format, which consists of a short header, describing the data size, type and representation, and the data set itself. A detailed format description can be found on the RAT Homepage [1]. Multilayer images and images with a matrix representation (PolSAR) are stored in a pixel-interleave format in a single (big) file, in order to simplify block processing. However, it is possible to combine multiple files to polarimetric or interferometric data sets.

RAT can import the native formats of DLR’s E-SAR sensor and ENVISAT-IMS data. Additionally, RAT supports import of RSI-ENVI format, generic binary, and generic pixmap formats (png, jpeg and tiff). More import filters are currently under development. Export possibilities exist to RSI-ENVI, generic binary as well as png, jpg & tiff.

B. Single-channel SAR

This program part contains functions for processing conventional SAR images. Up to now, the development concentrated mainly on implementing standard SAR speckle filtering techniques. This is important, as standard remote sensing software includes only very few and partly even wrong or not correctly adjustable filter implementations. Additionally, some simple edge-detection algorithms are included. An analysis tool for point and distributed targets can be for example used to measure the effective number of looks or to estimate the image resolution.

In detail, current single-channel SAR functions include:

- SAR speckle filtering (Boxcar, Median, Gauss, Kuan, Sigma, Frost, Gamma-MAP, Lee, refined Lee)
- Edge detection (Sobel, Roberts, Maximum Gradient)
- Point and distributed target analysis (resolution, effective number of looks, …)
- Generic slant-to-ground range projection

It is planned to add tools for estimating texture parameters, as well as a general maximum likelihood classification module, which can be used with arbitrary stacks of images.

C. Polarimetry

This program part contains functions for processing polarimetric SAR (PolSAR) images. Here, the emphasis lies in the correct handling of complex polarimetric SAR data; amplitude data are not supported up to now. RAT can perform most of the standard transforms of SAR polarimetry, like basis transforms and target decompositions.

Polarimetric data are either stored in form of scattering vectors (equivalent to the SINCLAIR-matrix), or as covariance resp. coherency matrices. Finally, the popular Entropy/Alpha
classification scheme, including Wishart reclustering, is supported as well.

In detail, current PolSAR functions include:

- Polarimetric speckle filtering (Boxcar, Lee, refined Lee)
- Formation of covariance and coherency matrix
- Decompositions (Pauli, Entropy/Alpha, Eigenvalue, Sphere-Dipole-Helix, . . . )
- Polarimetric basis transforms (linear → circular, . . . )
- Polarimetric point target analysis
- Span calculation
- Polarimetric classification (Entropy / Alpha, Entropy / Alpha / Anisotropy, Wishart)

Although the PolSAR part of RAT is already well developed, still several additional modules are necessary and planned for the future. First, a polarimetric calibration module is planned; whereas the first step in form of the polarimetric point target analysis is already finished. Secondly, full support of partial polarimetry (only two channels) is underway. This is of special interest, as most modern spaceborne sensors do or will provide such an imaging mode.

D. Interferometry

This program part contains functions for processing interferometric SAR (InSAR) images. Currently, only some basic InSAR routines are included in RAT, which are not well suited for professional InSAR data processing. It is possible to form interferograms out of two individual images, to coregister them and to estimate its phase and coherence. Additionally, a linear flat-earth component can be estimated and subtracted from the interferogram.

In detail, current InSAR functions include:

- Coarse image coregistration
- Interferogram formation
- Flat-earth removal (linear & from file)
- Phase noise filter (Boxcar & Goldstein)
- Coherence estimation (Boxcar & Gauss)

The InSAR part of RAT is very basic, and several additional modules are necessary before RAT becomes useful for more than educational purposes. Most important is the inclusion of phase unwrapping techniques, spectral filtering techniques (baseline & Doppler) and possibly methods for handling of orbit / track data. However, RAT is not intended to be another fully-featured InSAR package. Future development will focus more on InSAR image processing functions (i.e. filters, . . . ), than on providing methods for high precision DEM generation.

IV. PLATFORMS

RAT is available on the web and distributed under a free software license [1]. The distribution includes its complete source-code, as well as a binary version, which can be executed using the free IDL virtual machine [2] under various operating systems, including Linux, UNIX and MacOS-X.

The main development platform is Linux. It is tried to support Windows, too. This is quite easy using IDL and in general RAT on Windows should work fine. However, testing is done on Linux and there might be some problems left when running RAT under Windows.

V. LICENSE, TERMS OF USE

RAT is open-source software and can be used free of charge. However, in order to get some feedback about its user base, it is distributed as ’postcard-ware’. This means that one may
copy and use it as much as one likes, but that it is required to register each copy of the software by simply sending a postcard to the RAT team (local motives preferred). The address is:

RAT Team  
Technical University of Berlin  
Dep. of Computer Vision and Remote Sensing  
Straße des 17. Juni 135, EB9  
D-10623 Berlin, Germany

For details of the license, particularly concerning redistribution and usage of the RAT source-code in commercial software projects, please have a look at the complete license agreement at the RAT web site.

Generally, RAT is planned as an open project, and external contributions are welcome. Anybody, who likes to promote his own special algorithms by adding it to RAT, is encouraged to contact the authors for more information.

VI. SUMMARY & OUTLOOK

RAT is a new tool for advanced SAR image processing. It tries to combine modern algorithms with an easy to use graphical interface. RAT provides visual feedback of all operations on the screen in an optimized way. This is important in particular for unexperienced users, who are not used to the characteristics of SAR data. Different data representations are automatically displayed correctly and can be saved as pixmap graphics or in binary form for further processing in other software.

RAT is mainly intended to be an experimental platform, where new SAR methods can be implemented, tested, and also provided to the scientific community. As mentioned before, many promising algorithms are never used in practice, as they are only available to the original developer. RAT, as an open tool, might be a good place to better distribute such methods, even when they are not yet perfect and stable.

In future, the core development team at the Technical University Berlin will more concentrate on the optimization and extension of the main RAT framework, than on the implementation of new algorithms. However, it is planned to develop several new modules in the frame of student projects, graduation and PhD theses. In fact, it was observed that students were significantly better motivated when recognizing that their work is becoming part of an ongoing bigger project, which is of general use.

An important topic, which is still missing in RAT, is the inclusion of methods concerning polarimetric SAR interferometry (PolInSAR). Up to now, no PolInSAR software is publically available. Nevertheless, PolInSAR is currently an important research topic and the inclusion for at least some basic PolInSAR algorithms will be the next big development step. However, as this requires various modifications in the base of RAT, this will not be an easy task.

Another interesting topic, for which plans to address it in RAT exists, are image recognition techniques. This includes in particular shape and object based methods, for single-channel and polarimetric SAR images as well. Also the addition of advanced image clustering and segmentation techniques fall into this topic.

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