

Sensor and Data Fusion Contest: Information for Mapping from Airborne SAR and Optical Imagery

Olaf HELLWICH*, Christian HEIPKE**, Birgit WESSEL*

*Chair for Photogrammetry and Remote Sensing
Technische Universität München, D-80290 Munich, Germany
Phone: +49/89/289 22677, Fax: +49/89/280 9573
E-mail: Olaf.Hellwich@photo.verm.tu-muenchen.de

**Institute for Photogrammetry and Engineering Surveys
University of Hannover, Nienburger Str. 1, D-30167 Hannover, Germany

Abstract— The concept of a sensor and data fusion contest on topographic mapping from SAR and optical imagery is presented. Potential participants are introduced to topic and test which is scheduled to be started in summer 2001. The image data to be used in the test will have a spatial resolution of approximately 1 m or better. The SAR data will be multi-frequency polarimetric INSAR data, the optical data multi-spectral. The goal of processing is the extraction of topographic objects which are commonly subject of mapping projects, e.g. roads, built-up areas and other land cover/land use classes. The final scope of the test will be defined after interaction with potential participants of the test. Besides the image data, digital reference maps will be compiled for the test sites. For this task, contributions from e.g. official mapping authorities would be very valuable.

The data fusion contest will be organized in the framework of the IEEE GRSS data fusion technical committee (DFC), the ISPRS working group III/6 "Multi-Source Vision" which both have strong relations with scientists active in research on multi-sensor fusion and automation in mapping, and – as the provider of the main organizational framework – the European Organization for Experimental Photogrammetric Research (OEEPE) which is the research platform of national mapping agencies and other institutions regarding technology developments to optimise the use of core data in a geoinformation infrastructure context.

Keywords— data fusion, multi-sensor, test set-up, sensor contest, data fusion contest

I. INTRODUCTION

For mapping tasks such as the acquisition of topographic objects or the generation of digital elevation models (DEM), mainly panchromatic optical imagery is used. Yet recently, also various types of multi-spectral images have been applied allowing to acquire additional object-specific characteristics making object extraction more robust. Besides this, synthetic aperture radar (SAR) imagery has been in use for a number of years with a strong emphasis on satellite images such as data from ERS, J-ERS or RadarSat. While these images can be successfully used for a number of tasks, topographic mapping in scales such as 1:25,000 or 1:50,000 is very difficult, mainly due to the rather coarse ground sampling distance. Recently, airborne SAR images have increasingly become available and are gaining in importance, especially when used in the interferometric mode for the generation of digital terrain models, or the polarimetric mode for the extraction of structural object information.

In this scenario of practical applications two questions are remaining: (1) Can state-of-the-art airborne SAR compete with optical sensors in the mapping domain? (2) What can be gained when SAR and optical images are used in combination, i.e. when methods for information fusion are applied? Presently,

there are no clear answers regarding these questions. On the one hand, there are indications that in the future airborne SAR images will probably also play a bigger role in topographic mapping due to their major advantages, namely independence of day light and of cloud cover. On the other hand, the interpretation of SAR images is difficult for a number of reasons: the geometry and the spectral range of SAR is different to optical imagery and – what is more important – different to how the human eye works. In addition, the reflectance properties of objects in the microwave range depend on the used frequency band and may significantly differ from the usual assumption of more or less diffuse reflection at the Earth surface. This effect can be particularly strong for buildings or metal surfaces. Speckle, a consequence of the coherent radiation needed to exploit the SAR principle, and other disturbing factors further complicate the interpretation. Therefore, mapping staff such as photogrammetric operators often experience difficulties in interpreting SAR imagery for topographic mapping.

Therefore, a test on topographic mapping from SAR and optical imagery is proposed. Its aim is to study in as much detail as possible the potential of airborne SAR and multi-spectral optical imagery for topographic mapping in the scale range of 1:25.000 to 1:50.000. Based on orthoimages of one or more study area/s test participants should visually interpret the imagery on the screen, and capture the topographic objects interactively. The evaluation of the test results will be based on reference data. Besides a graphical comparison of different plots, quantitative results (e. g. the number of objects which could be detected correctly/which were labelled correctly, the geometric accuracy of the extracted objects etc.) will be determined. It will also be studied which attributes can be derived from the test data. In a second and third phase, test participants will be using automatic methods for object extraction and methods of data fusion, respectively.

II. TEST DATA

The image data to be used will have a spatial resolution of approximately 1 m, or - especially in case of SAR data - better. The SAR data will be multi-frequency polarimetric interferometric data, the optical data multi-spectral. Both optical and SAR sensors will be leading-edge airborne systems being under continuous revision which is why the exact parameters of

sensors and data are not yet known. The goal of processing is the extraction of topographic objects which are commonly subject of mapping projects, e.g. roads, built-up areas and other land cover/land use classes. The final scope of the test will be defined after interaction with potential participants of the test. Besides the image data, digital reference maps will be compiled for the test sites. For this task, contributions from official mapping authorities would be very valuable.

For the test, existing imagery from commercial companies or from data users/owners shall be used. Beforehand, for each data set the legal conditions of data use by the test participants have to be clarified. It would be preferable to use data which are free of charge. Regarding this matter, any information about benchmark data sets already in existence is very welcome.

Figure 1 shows a multi-sensor sample data set giving an impression of the mapping potential of optical and SAR data, both in a competitive as well as a complementary sense. Figure 1 a) shows X-band SAR intensity data, Figures 1 b) to 1 d) polarimetric L-band SAR intensity data in VV, HV and HH mode. Figure 1 e) is an optical image. Figure 1 f) presents reference data in form of a topographical map.

III. SENSOR AND DATA FUSION CONTEST

The test will be conducted in three phases. In phase 1, the participants will derive a visual interpretation of the data. The results will show the information content of the data independent of the performance of specific automatic object extraction methods and software. In this phase, mapping authorities commonly active in state- or country-wide mapping projects can give valuable contributions to the contest.

In phase 2, automatic object extraction procedures will be applied to each sensor's data separately. Regarding data fusion, the results will be reference data for the performance of object extraction without use of multi-sensor data. They will at the same time represent the outcome of a competition of sensors. Possibly, the question can be answered whether SAR is already an alternative means of data acquisition in mapping projects compared with optical sensors or whether it even outperforms optical sensors. In this phase, the alternative use of only partial data of one or both of the sensors may be requested from the participants. Object extraction results will be analysed by comparison with the digital reference maps. In phase 2, any party (private company, governmental authority, university or research institute) can compete successfully by presentation of results reflecting its specific expertise, e.g. in automatic extraction of a specific class of objects, or in compilation of maps fulfilling specific official requirements.

In phase 3, mapping will be conducted based on data of both sensors, i.e. by multi-sensor data fusion. This phase will give any participant interested in research on data fusion a chance to prove how valuable multi-sensor data fusion is by demonstrating the degree of improvement in accuracy, correctness, completeness, robustness, or scope of object extraction.

IV. ORGANIZATIONAL MATTERS

The test will be organized in the framework OEEPE in co-operation with the IEEE GRSS data fusion technical committee (DFC) and ISPRS working group III/6 "Multi-Source Vision" which both have strong relations with scientists active in research on multi-sensor fusion and automation in mapping.

One can pursue at least three different ways to define the topographic objects to be dealt with: (1) the pilot centre defines a set of objects of interest such as roads, buildings, settlement areas etc. in the preparation phase of the test, (2) these objects are defined and agreed upon by the participants immediately after the beginning of the project, (3) each participant is free to define his own set of relevant objects which should preferably come from the national topographic data base. It is anticipated that (1) and (2) lead to a closer co-operation between the participants which is desirable. (3) should therefore only be pursued if (1) or (2) are not feasible for any reason. After collecting the results the pilot centre will have to homogenise the individual interpretation results in order to draw meaningful conclusions.

Due to the general tendency in photogrammetry and topographic mapping towards multi-sensor systems and especially due to the increasing importance of SAR in this context, the proposed test is seen as important for all groups within the mapping community. Some characteristics of the images to be used for the test, the specific image acquisition parameters (flying height, precise ground resolution etc.) and site location/s still have to be defined. It is certainly advantageous to have more than one single test site in order to be able to study a variety of phenomena. These issues should be discussed and solved in the definition phase of the project which is supposed to be started by the end of May 2001. Any party interested in participation to the contest is kindly invited to contact the first author of the paper.

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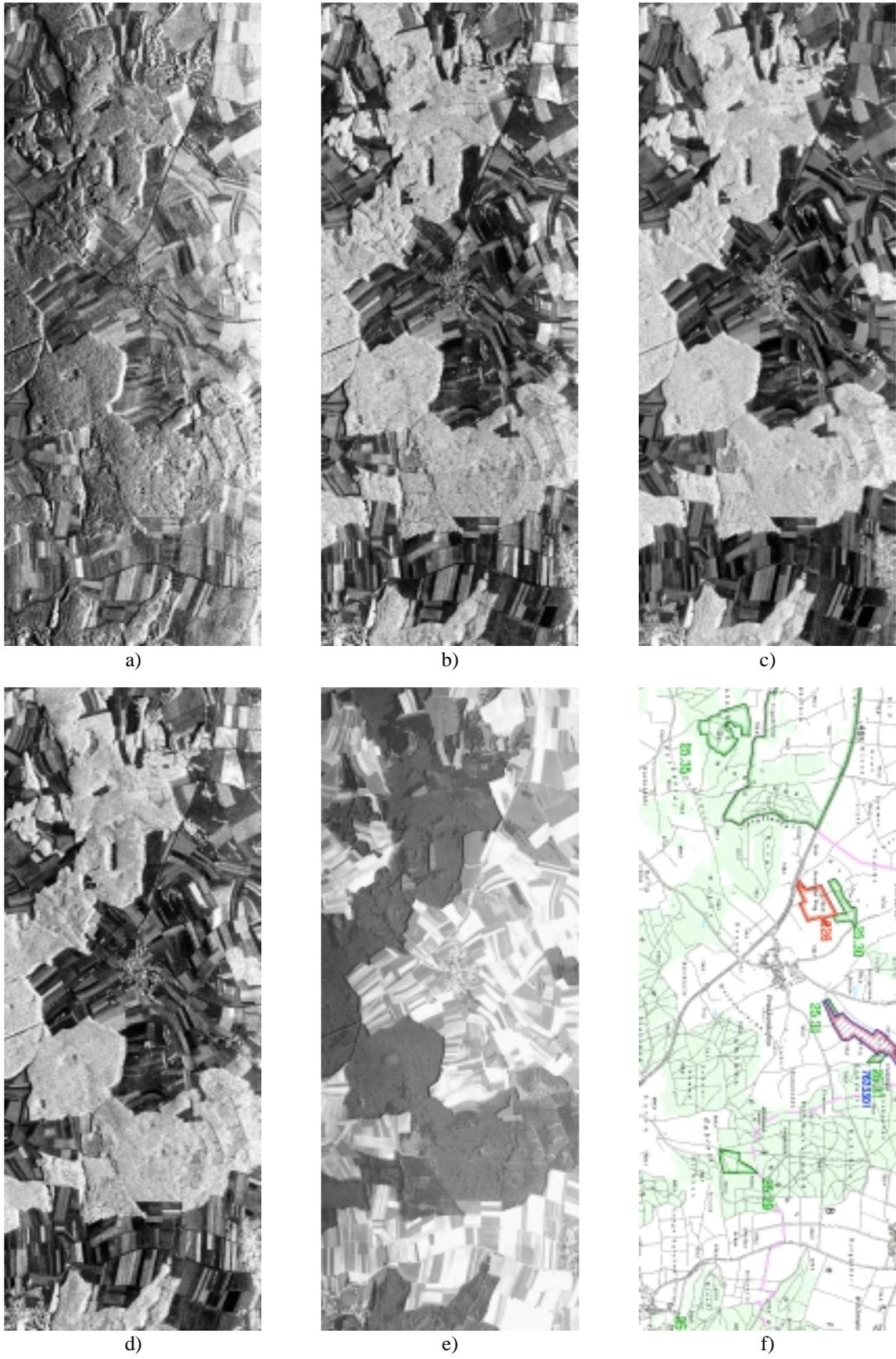


Fig. 1. a) X-band VV-, b) L-band VV-, c) L-band HV-, d) L-band HH-polarized multilook SAR intensity, e) panchromatic optical image, f) map. Scale 1:65,000.