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Milan Bajic
CROMAC

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Survey of Suspected Mined Areas From a Helicopter

While awaiting the results of airborne remote sensing projects, available in a few years, a singular solution is recommended. Remote sensing from a manned helicopter for the general survey of minefields and risk-suspected areas has already been developed and was operationally validated in 2002 and 2003 in Croatia. 

Introduction

The ground-based general survey of minefields and of suspected areas is often unaffordable due to limited access. This constraint can be avoided by the use of airborne remote sensing. Airborne remote sensing methods and technology were, in 1999, only partially suitable for the needs of humanitarian demining. The first project, involving airborne remote sensing aimed at the needs of humanitarian demining, was an excellent means of understanding the complexity of the mine scene. There are important lessons to be learned from the project. An interesting approach was the use of an airborne as a platform and ultra wide band radar and electro-optical sensors. In 2003, airborne remote sensing methods and technology reached maturity, permitting their use in wide areas, general surveys and possibly for technical surveys of mined and mine-suspected areas. Even though no operational system was available untill now, we will know their potential contribution to humanitarian demining in 2005 and 2006.

In addition to these projects, which are solely related to humanitarian demining, there are other projects involving airborne landmine detection that are less promising the their use in wide areas, general surveys and possible for technical surveys of mined and mine-suspected areas. Even though no operational system was available until now, we will know their potential contribution to humanitarian demining in 2005 and 2006.

The basic assumptions for the successful development and deployment of the described general survey were:

- Use the small minefield (e.g. Bell-206) that is available in each country contaminated by landmines and UXO, and avoid the excessive development of a platform.
- Use experienced ground crews and train them for aerial survey of minefields and risk-suspected areas.
- Use the commercial off-the-shelf (COTS) sensors, computers and Global Positioning System (GPS) receivers.
- Use fully digital electro-optical cameras from thermal infrared, near infrared and visible wavelengths, and enable full interoperability with geographic information systems (GIS) and Mine Action Impact Scenarios (MIS) of mine action centers (MACs).
- Use simple and cheap sterilized gloves that enable one to preset imaging angles manually.
- Provide passive dumping of sensor vibrations.
- Integrate all sensors, frame grabbers, personnel computers and GPS receivers into the acquisition system.

For the installation of the system on the helicopter (in our example, the Bell-206), it is desirable to reduce blurring of imaging. For Bell-206, and based on the digital VNIR and TIR sensor, a platform that enables different modes of imaging (VNIR) or of spatial sampling (HLSL). For TIR, imaging was applied to the original software of the camera, VNIR images have several options: four channels (each eight bits), three channels (each 16 bits) or single channel (eight or ten bits). During the acquisition, images are stored in specific format that provides the highest throughput, while they are exposed in tagged information file format (TIFF) for further use. For each image, basic data is provided (time of recording, gain of each channel, exposure time) that enables synchronization and geo-referencing. The trade-off among spatial coverage, oversampling, and resolution is accommodated by the selection of optical objectives having different focal lengths, the selection of a number of channels, and the selection of radiometric range and height above the terrain.

The helicopter's flight above terrain for Bell-206 is 130 m as specified by the helicopter safety rules (dead man curve). The minimum velocity of the flight at the lower height is desired to reduce blurring of images. For Bell-206, and based on the digital VNIR and TIR sensor, a velocity of 20 m/s was approved as the lowest and most suitable velocity. In comparison to aerial video imaging by television cameras, digital sensors are much more resistant to blurring caused by radial

Figure 1: A small helicopter was approved as suitable for remote sensing of minefields and risk-suspected areas. Deployment for operational use could be larger than four or five years. While awaiting the results of these projects, the discrepancy between needs and available operational airborne technology for general surveys can be compensated for by the use of sustainable and already developed simpler solutions. In Figure 1, we present an application of remote sensing from a manned helicopter for the general survey of minefields and suspected areas, which was developed and operationally validated in 2002 and 2003 in Croatia. The example, Figure 1 shows the potential to immediately (rather than in five years) establish sustainable general survey of minefields and suspected areas. More importantly, this solution is feasible in many countries contaminated by landmines and UXO, at a cost that is at least five to 10 times less than the cost of one of the projects that were mentioned previously. In the following section, we present the basic assumptions for a general survey from a manned helicopter and we outline the system and its operational validation.

Basic Assumptions

Multi sensor Acquisition System On Board Helicopter Bell-206

This system uses digital, electro-optical sensors, computer-controlled acquisition and GIS-based navigation. The sensors are (See Figure 2):

- Four-channel digital camera (MS-3100), 1392x1029 pixels, for three visible and one near infrared band (VNIR), from 0.4 to 1.0 m, with optical objectives having focal lengths of 17, 24 and 28 mm.
- Thermal infrared (TIR) camera (modified THV-1000): 600x390 pixels, 8 bits, for wavelengths 8-14 m with two fields of view.
- Phase-synchronous line scanner (HSLS): 585 pixels, eight bits and 99 channels for wavelengths 0.43 to 1.0 m.

Each sensor has an independent acquisition system (frame grabbers, acquisition software, personal computer) and can be used separately. For VNIR and HLSL, sensors were developed with acquisition software that enables different modes of imaging (VNIR) or of spatial sampling (HSLS). For TIR, imaging was applied to the original software of the camera. VNIR imaging has several options: four channels (each eight bits), three channels (each 16 bits) or single channel (eight or ten bits). During the acquisition, images are stored in specific format that provide the highest throughput, while they are exposed in tagged information file format (TIFF) for further use. For each image, basic data is provided (time of recording, gain of each channel, exposure time) that enables synchronization and geo-referencing. The trade-off among spatial coverage, oversampling, and resolution is accommodated by the selection of optical objectives having different focal lengths, the selection of a number of channels, and the selection of radiometric range and height above the terrain.

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speed and vibrations. This enables the use of un-stabilized gimbals and provides surprisingly good images.

A digital moving map for measurement and recording of the real-time position the platform by means of the GPS, is applied for the mission planning, flight control and reporting (Figure 3, Figure 4). The flight planning begins with a statement of needs defined by MAC specific information that was required by MAC about the given area of interest (AOI). The next step is planning the routes in accordance with characteristics of the terrain, sun position, expected wind directions and selected modes of imaging. After acquisition, images and data are exported to the interpretation computers. The flight route, data and the logs of images are combined. This enables geo-referencing of images. The next step in processing is derivation of the flight routes (Figure 5) can produce them or, if needed, geocoding can follow this process (Figure 7).

Furthermore, interpretation is performed on original images if spectral information is more important than spatial information. Interpretation of mosaics occurs in the opposite case. Basic kinds of output of the survey are:

- Raw images (Figure 8)
- Vectors of detected objects (Figure 5)
- Non-geocoded mosaics (Figure 6)
- Geocoded mosaics (Figure 7)
- List of detected minefield indications, description, attributes and coordinates

Classification map and many other maps depending on purpose and aim of the aerial survey.

The aerial general survey of minefields and suspected areas is indeed an intelligence-gathering, processing and dissemination system—not a cartographic system. Therefore, it is not always necessary to geocode mosaics or single images (namely, if vector data are needed as an output, it is enough to geocode output vector). Which solution to apply depends on the requirements of MACs. Following are examples of typical tasks of an aerial survey:

- Detect and delineate trenches; determine coordinates
- Detect and delineate man-made embankments; determine coordinates
- Detect and identify bunkers; determine coordinates
- Detect and delineate agricultural areas in use that were part of risk-suspected areas in M5s and GIS of MACs; determine coordinates
- Detect, identify and delineate access roads and paths deep in the suspected areas and minefields; determine coordinates
- Detect, identify and delineate access paths to rivers, brooks, channels in the minefields and suspected areas; determine coordinates
- Detect, identify and delineate rivers, brooks and channels in the suspected area and minefields; determine coordinates
- Detect and identify bridges across the rivers, brooks, channels in the suspected area and minefields; determine coordinates

Typical Tasks

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Figure 4: A view of the flight route on the topographic map of the scale 1:25,000. This serves as an example of the aerial survey of the electricity high tension network (left of the towers, vegetation) and access field roads from the asphalt road on the left side to the network corridor.

Figure 5: The output of the survey is non-geocoded mosaics produced by registering images to images. The example shows mosaics of five thermal infrared images collected by THV-1000 from 500 m above terrain. Trenches (T) are easily detected—they appear as waved bright or dark lines in the thermal infrared images. They are reliable indicators of mined area.

Figure 6: The output of the survey is non-geocoded mosaics produced by registering images to images. The example shows mosaics of five thermal infrared images collected by THV-1000 from 500 m above terrain. Trenches (T) are easily detected—they appear as waved bright or dark lines in the thermal infrared images. They are reliable indicators of mined area.

Figure 7: Output of the survey is the geocoded mosaic. A circle on Fig. 4 marks an example of the mosaic of an area. The mosaic is overlaid over the map of the scale 1:5,000. The aim of the aerial survey was to provide information about the status of the access road that was out of use for more than 10 years.
Conclusion

The airborne multisensor system, on board helicopter Bell-206, was directed primarily toward minefield research for the general survey (as a complementary process to the ground-based general survey). But it is not limited to these purposes. Other applications are possible. This is the first fully digital airborne multisensor system in Croatia. Its development was motivated and enabled by the scientific project ARC, funded by the European Commission, and it was realized through the potential, experience and human resources already existing in Croatia in the field of airborne remote sensing.

*All graphics courtesy of author.

**References**


**Contact Information**

Milan Bajic, Assoc. Prof., D. Sc. Geodetic University of Zagreb Scientific Council of CHROMAC Ullica grade Vukovarska 226 c 10000 Zagreb, Croatia

Tel: +385 98 460 917

E-mail: milan.bajic@eng.unizg.hr

**By Nicole Kreger, MAIC**

**Background: A Need for Improved Mine Detection Techniques**

The Mine Action hopes to fulfill current demining and survey needs. This airborne mine detector makes use of radar technology and an airborne platform to quickly scan an area for mines. One of the most effective uses of this technology would be for area reduction. Distinguishing minefields from clear areas is extremely important, because people in mine-affected countries will often avoid using clear land for fear that it is contaminated. Effective area reduction helps return land to those people quickly and also allows mine action agencies to mark land that is contaminated so that civilians avoid danger until the mines can be cleared.

**The MineSeeker Platform**

The MineSeeker makes use of Ultra Wideband Synthetic Aperture Radar (UWB SAR), which is able to penetrate objects such as foliage and can detect objects buried in the ground. UWB SAR is able to produce the highest resolution images of any radar of its kind. Use of this radar requires as little vibration as possible in an environment that is nearly free of metal. Other airborne systems can fly steadily and slowly enough over an area to use UWB SAR, or are not big enough to accommodate UWB SAR. Thus, the MineSeeker Airship is perfect for the job as it “provides a mobile, stable platform that has long endurance, low noise and vibration, no propeller downwash (downward air pressure, possibly strong enough to trigger a mine) … exceptionally low risk of critical failure, a large payload capacity and a good operational environment.”

**Minesecaer Trials**

In January 2000, the MineSeeker underwent trial usage at the Defense Evaluation and Research Agency (DERA). This marked the first airborne trial using UWB SAR of this type in the world. The trial determined that the airborne system was as at least as effective as previously conducted ground-based trials and led to further development of the MineSeeker system.

The United Nations Mine Action Coordination Center (UN MACC) in Kosovo requested that the MineSeeker be deployed there as a simple reconnaissance and survey tool. A prototype was sent to Kosovo in the fall of 2000, which enabled the MineSeeker to be used in a red mine-affected environment. It marked the world’s first use of an airship in a humanitarian role and in a post-conflict environment.

The UN in 2000 showed that the MineSeeker is able to detect mines and UXO that are laid on the surface, hidden by foliage and buried in the ground. The UWB SAR scans areas at a rate of 100 sq m per second, and it records an overwhelming amount of information. As MineSeeker Founder Mike Kendrick put it, “In that second, it transmits as much data as is encoded in the entire British Library.” Such information would be useful to any number of organizations and government ministries.

From left to right, Mike Kendrick of the MineSeeker Foundation, Col. Alistair McAlais of Cranfield Mine Action and David Partridge of Quest2 stand in front of the MineSeeker Airship.

**It’s a Bird, It’s a Plane—It’s the MineSeeker Airborne Mine Detector!**

Partnering with QinetiQ and The Lightship Group, the MineSeeker Foundation is developing a system to revolutionize mine detection. By deploying the first operational airborne landmine survey system, the foundation aims to provide the mine action community with a quicker and more efficient survey tool. Additionally, the MineSeeker has the potential to be useful in a number of other areas necessary for development in mine-affected countries.