Telematics for monitoring environmental emergencies

Communication and Navigation Services 2 - Guidance for the future

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1. Summary

A combination of remote sensing techniques and telematics makes it possible to detect, monitor and manage environmental emergency situations. The basic techniques are mostly developed far enough to be applied directly. The main technical challenge is to integrate the techniques in an optimal way. The most challenging hinders for operational use of this approach are bureaucratic obstacles, like policy for data distribution and pricing.

2. Introduction

Each year, our environment is exposed to a series of major hazards like forest fires, oil spills, floods, earthquakes, etc. A single such event may cause major damage to people or the ecological system in general. Emergency management authorities report that in order to reduce the effects to a minimum, it is of the utmost importance to be able to detect and report such events quickly and accurately. Current procedures are mostly manual and often time consuming. Recent developments within telematics and remote sensing technology make it possible to detect, monitor and report many such events in a much more efficient way.

Forest fires are a major problem in southern Europe. For example, 1994 was an extremely hazardous year in Spain with loss of human lifes and large economic consequences. At least 20 people died, and 138,000 hectare burned down. Early detection and efficient monitoring for assessment management of fire fighting will have great impact.

Oil spills are a major source of marine pollution. The amount of oil spill from rinsing tankers and "natural losses" in the Mediterranean alone is estimated to 600,000 tons yearly (three times the Amoco-Cadiz pollution). The problem is correspondingly large along the European Atlantic coast. Today, it is impossible to enforce laws that regulate such oil spills since there are no effective monitoring systems.

During the last years, several major floods have occurred in Europe. Use of a satellite imagery in combination with other data sources can represent a very cost-effective tool to monitor large areas and provide decision support for counteractions.

One of the most serious emergency situations is earthquakes. An earthquake may result in the loss of thousands of lifes and loss of property corresponding to billions of ECU. Earthquake

early warning is possible by interferometric satellite radar observations. Very small movements in the earth's crust, and indication of a potential earthquake, can be measured by this technique.

The typical environmental emergency monitoring approach will be to have a monitoring center supported by powerful information technology. The center will be the central information node that finds and extracts the important information and distributes it to the users, like national and regional pollution authorities, counteraction forces and the public.

The TAP project ENVISYS is a serious step towards the application of remote sensing and telematics to handle environmental emergency situations in a much more efficient way than has been possible with traditional techniques. ENVISYS is demonstrating how these technologies can be used for marine oil spill detection.

3. Contribution to the theme

While the group of environmental emergency situations covered here are very different, they have all certain similarities:

1. Potentially serious to people and environment
2. Sudden appearance
3. Geographical extended
4. Potential of rapid development

From the first characteristic, it can be concluded that environmental emergency situations are of utmost importance to be handled. However, one has so far had less efficient tools for this purpose. The combination of 2 and 3 has until recently made it difficult to efficiently detect and monitor such phenomena. The advent of high spatial resolution satellite remote sensing has made this possible. The 4th characteristic makes it necessary also to monitor the phenomenon frequently. The same remote sensing technology makes this possible. However, to make the remote sensing data useful, information technology is a requisite. First, it is necessary to transfer the data fast from the satellite ground station to the emergency monitoring center. Furthermore, the data amounts may be so huge that automatic or semi-automatic processing of the data is necessary. When the emergency situation is detected, it is necessary to combine a lot of data in order for the operator to be able to draw the right conclusions. Note that several data sources may be distributed, and require rapid transfer of data.

From this brief description of the situation, one can draw the conclusion that remote sensing is a promising approach, however, additional technology is strictly required in order to be able to use the approach. What is needed is efficient information technology solutions.

How is remote sensing technology able to detect these emergency situations?

- *Forest fires*. Forest fire detection is based on data from the visible or thermal infrared part of the spectrum. The signature in thermal infrared is easiest to detect. The energy emitted by the fire will create high intensity compared to the surrounding areas. In the visible part of the spectrum, the smoke from the fires is most dominating (Wagner 1994).

- *Oil spill*. Oil-spill detection by Synthetic Aperture Radar (SAR) is based on the dampening effect oil has on capillary and short ocean surface waves. The microwave backscatter from the ocean surface is reduced in areas where oil is present. The result is that oil slicks turn out as dark areas on a brighter background (Lichtenegger 1994).
- *Floods*. Floods are detected by major changes of a water-body's border. This can be detected well in both optical and microwave wavelengths (Blyth and Biggin 1993).
- *Earthquakes*. SAR interferometry measures the phase difference between two images, corresponding to the change in the round-trip path length of the radar waves to the same ground point (Massonnet, 1993). Terrain surface shape and change can be measured down to the centimeter level by SAR interferometry. Hence, the technique can be used to detect small earth crust movements that may be an early warning of an earthquake.

The main technological challenges for applying these remote sensing data for environmental emergency monitoring, are the following:

1. Rapid transfer of huge amounts of data from satellite ground stations to the user
2. Rapid data analysis of the satellite data in order to detect emergency situations
3. Efficient ways to combine satellite data and ancillary data in order for the operator to assess the situation
4. Efficient ways to present the data to the users to make them able to make the right decisions for warnings and counteractions

The satellite data amounts necessary to transfer rapidly to the monitoring center may be from a few megabytes up to a gigabyte. With the bandwidths available today through high-speed communications networks and with the plans for new information highways coming up, bandwidth is not likely to present any problems.

Rapid analysis of the huge amounts of satellite data requires automatic or semi-automatic image analysis. It may be necessary to implement the behavior of a experienced human image analyst into software, as done for oil spill detection in ENVISYS. Or it may be necessary to use analysis techniques that are much more powerful than visual interpretation alone (like for SAR interferometry). The intensive research in image analysis and pattern recognition the last 10-20 years makes this possible now.

It is a challenge to combine all the information required. It may be necessary to add ancillary data, like meteorological data, to do a proper assessment of the situation. The technology for this is present through the application of Internet and Internet-accessible databases. There are still bureaucratic obstacles, like data policy and data pricing that may slow the development within this area, but the technology is here.

Data must be combined and presented in an optimal way to make the user be able to make the right decisions. A wrong decision may be fatal, so this is crucial. A combination of Geographical Information System (GIS) tools, ordinary database tools and an efficient Graphical User Interface (GUI) makes this possible. The challenge is more a problem of integration than the need for more development of each of these technologies.

The ENVISYS project demonstrates a solution for emergency detection, monitoring and management utilizing the abovementioned technologies (Solberg and Theophilopoulos 1996 and 1997). The system automatically transfers satellite data as they are available from the

ground station to the monitoring center. The data are analysed automatically and immediately, and the attention of the operator is called if a suspicious situation is detected in the satellite data. Satellite images, map data, wind data and sea current data are merged together using GIS, RDBMS and GUI technology in order to support the operator and users to make the right decisions. One is also supported with oil spill development simulators and a database of cleanup equipment to make appropriate decisions.

4. Conclusions and recommendations

The powerful combination of remote sensing techniques and telematics makes it possible to detect, monitor and manage environmental emergency situations. The basic techniques are mostly developed far enough to be applied directly. The main technical challenge is to integrate the techniques in an optimal way. A first step in this direction is demonstrated in the ENVISYS project for the oil spill case.

Even if the basic technology exists, there are several obstacles that must be solved for the use of this approach operationally:

- Satellite ground stations and space agencies (in particular ESA) are in general not aimed to deliver real-time data (one of very few exceptions to this is Tromsø Satellite Station in Norway). The approach cannot be used before this policy has been changed and implemented.
- Detailed map data is in some countries not accessible in general, mostly due to military restrictions. If this policy is not changed, operational implementation will be more slow and costly.
- Ancillary data, in particular meteorological data, is often not made available in real time and/or in digital form. This may be due to data protection/pricing policy. Emergency monitoring will not be powerful enough if such data are not made available via data networks.

References

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See `www.impetus.gr/envisys.htm` for more information on ENVISYS.