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The introduction of remote sensing into the European knowledge society: an approach

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ABSTRACT: Expertise in science and technology is often confronted with the issue of applicability, adaptability and acceptability of its accomplishments by the final receptors/ potential beneficiaries, i.e. the society, despite the fact that legislation and policy frameworks are continuously set. The general levels of scientific culture within society will increase, since increased understanding by the citizen side is required. The challenge remains to make lifelong learning attractive and rewarding in order to enhance the skills and competencies everyone needs in every day working life.

Towards this direction, this study focuses on diffusing remote sensing knowledge and applications (environmental, agricultural, urban, etc.), used only by specialists today, to a broader and interdisciplinary audience of (a) students in high schools and (b) professionals. Depending on the audience to be addressed in each case, the tutoring content and presentation methodology will be flexibly adjusted. There is always the necessity to choose the thematic application range and depth of the methodology that the audience will be exposed to. This selection procedure expands to the data needed, as well as to adequate hardware and software tools.

1 INTRODUCTION

Science and technology are evolving at an increasing rate these days. What is considered a breakthrough today soon becomes common knowledge amongst the scientific community, and within a few years it is considered "old news" and even obsolete knowledge. Additionally, these innovations are making the transition from theoretical advances to practical applications in a short period of time. Even though the communication pathways within the scientific community are very efficient, and the European Union is continuously establishing relevant legislation and policy frameworks to achieve this goal (Council Decisions 1720/2006/EC, 2318/2003/EC), expertise is confronted with the issues of applicability, adaptability and acceptability of its accomplishments by the final receptors and potential beneficiaries, i.e. the society.

As citizen understanding requires constant enhancement, the challenge remains to make lifelong learning attractive and rewarding, in order to enhance the skills and competencies everyone needs in every day working life. The rate at which new scientific innovations and technologies are finding their way into the people's everyday life is constantly upgrading their technological status quo. One example of such technologies is remote sensing.

Remote sensing science and the relevant technologies are constantly employed into more applications. People are increasingly exposed and find themselves using these technologies, from the simple use of a digital camera, to the "bird's view" perception of a disaster area provided by a satellite image in the media. However, their understanding of remote sensing, its functionality and the extent of its applications is severely limited. As a result, people are restricted in their ability to fully comprehend its capabilities and employ remote sensing for information acquisition.

In order to disseminate remote sensing knowledge to a broader and interdisciplinary group of high school students and professionals that would benefit from this knowledge, an educational course needs to be designed and implemented.

2 TARGET GROUP SEGREGATION

In order to convey any knowledge regarding remote sensing, it is important to identify the social groups that would benefit from this knowledge and subsequently pinpoint the specific requirements of each group. There are two target groups that this study will focus on; high school students and professionals, whose working practice would benefit from using remote sensing:

a) High school students are identified as the pupils attending secondary education in a European country. As a general rule, secondary education lasts between 6 to 9 years and secondary school students are aged between 10 and 19 years of age. Even though this group contains people with common attributes, there is a large amount of variability within it. Younger students are taught more general and basic knowledge for each subject, whereas older students build on the existing knowledge. Using this characteristic, the secondary school students are divided into two groups. One group consists of younger students (ages 10 to 15, group 1) and the other of more mature students (ages 16 to 19, group 2). Each of this group will be studied separately with regard to the nature of remote sensing related knowledge they can grasp.

b) With a wide range of applications, there is a multitude of professionals who would benefit from being able to employ remote sensing in their work. As far as remote sensing education is concerned, the main parameter for dividing this group is the manner that remote sensing knowledge will serve those professionals. Hence, the professionals group can be further divided in two groups. Those oblivious or with little knowledge about remote sensing, who could potentially benefit from acquiring such knowledge (group 3) and those interested in learning about remote sensing, because they are aware of the boons it will offer to their work practice and their ability to deliver (group 4).

3 REQUIREMENT IDENTIFICATION OF TARGET GROUPS

Students at the lower levels of secondary school (group 1) are beginning to develop critical thinking, and have some capability to absorb complex information (Inhelder & Piaget 1958). Their developed sense of logic, in conjunction with an active imagination, allows them to comprehend the earth's representation from a remote sensing point of view. However, their technical background is not sufficiently extensive to allow them to grasp the scientific details of the remote sensing principles. Scientific education at this level often employs visual and auditory means in order to attract and maintain the students' attention. Furthermore, it is common for practical experiments and puzzles to be employed in order to stimulate their critical thinking (Smith 2001).

Higher level secondary school students (group 2) are more mature than their younger counterparts. Their scientific background knowledge is more extensive, which allows them to comprehend the more technical side of remote sensing. Depending on the curriculum at this stage, most scientific schools have already taught the physics of waves, oscillations and electromagnetic spectrum, an integral part of remote sensing (Grimm & Riquarts 1992). Even students that have not received this information, whether due to the school curriculum structure or because they have chosen a non-scientific education pathway, they have the mental capacity to acquire this knowledge.

Many professionals are involved in one of the many remote sensing application areas, but are unaware of its overall potential (group 3). It is important to educate this audience with the new scientific and technological advances of remote sensing. Since these professionals have a scientific background, the description of remote sensing functionality is simpler, compared to the case of secondary school students. The main focus should be on the details of the applications of remote sensing and highlighting the provisions of remote sensing in these areas.

In contrast to the previous group, professionals already aware of the value of remote sensing in their area of expertise have more focused requirements (group 4). Instead of general knowledge on remote sensing applications, this group needs to be informed about the most specific details of remote sensing use on their particular discipline. They require explicit tutoring on how to employ, manipulate, and extract information from remotely sensed data, as well as state-of-the-art information on the type of sensors, platforms and image processing software and methods available today.

4 DESIGN AND STRUCTURE OF A REMOTE SENSING TUTORIAL COURSE

4.1 *Tutorial content focus for each target group*

It is apparent that the resulting four groups have diverse educational background and requirements from earth observation products. The variable requirements and capabilities of each group suggest that individual modules will need to be designed, each focusing on the particular group in question.

Younger secondary school students (group 1) lack the knowledge regarding the specifics of the electromagnetic spectrum, which inhibits the explanation of the physical processes taking place during the acquisition of the remotely sensed data. For this group, it will only be possible to provide a general overview of the applications of remote sensing, without delving too deep into how these data are captured and used.

Despite these limitations there is still abundant material of spectacular satellite images and aerial photographs that can capture their attention with their bird's-eye perspective of features on the earth's surface, such as cars, trees, buildings, lakes, rivers and mountains. Examples of such data consist of images portraying the effects of natural disasters such as forest fires, floods, volcanic eruptions and tsunamis, as well as meteorological and urban satellite images. These images will be used to introduce some of the applications of remote sensing.

Later secondary school students (group 2) would also benefit from the display of such images, as they would serve as an ideal introduction into the capabilities of remote sensing. This group, however, can progress into more technical details of remote sensing, including electromagnetic radiation (EMR), its interaction with matter and spectral signatures (physical aspects of remote sensing), remote sensing platforms and sensors and elementary image processing.

The modules used for the two groups of secondary school students are also applicable for the group of professionals with a general interest in remote sensing (group 3). In this case however, in addition to a general overview of the applications of remote sensing, more focus should be placed on the specific applications of interest. The module content will need to be broken down in smaller modules, with each focusing on particular remote sensing application and providing more detailed information regarding this application.

On the other hand, professionals with a specific interest in a remote sensing application have more specialized requirements (group 4). In addition to the introductory material of the individual remote sensing application, even more information will be provided for each application, including data requirements, image processing techniques and an intense focus on the capabilities and limitations of the commonly used methods.

4.2 *Teaching methods and material requirements for each target group*

In addition to the variable teaching material used and the depth to which each group will progress, teaching methods and data, software and hardware requirements will also vary amongst the groups.

There are two main methods to achieve the transfer of knowledge to the audience. The first is the traditional teaching method in a classroom. The second method comes in the form of computer-based teaching modules, some of which are available on the internet for all interested persons to access. Numerous online modules have been designed in the past, some with a specific audience in mind and others simply conveying general remote sensing information (Short 2007).

All secondary school students respond better to visual and audio stimulation (Girard 1974). It is important to attract and maintain their attention through these means and

excite their intellectual functions by providing puzzles and tasks to accomplish. Interactive software displaying remotely sensed images (i.e. GoogleEarth) could also be used to underline the spatial element of remote sensing imagery. For these students, the presence of a lecturer will assist in maintaining their attention and conveying the information. This tutorial should consist of computer-based exercises for the introduction of the general remote sensing concepts accessible over the internet, as well as during the class. Additionally for the more mature secondary school students (group 2), the modules can have a more technical focus, with an introduction to remote sensing platforms, sensors and image processing and analysis. Teaching material should also be available online and provide the students with the option of further practicing in their own time.

Professionals would also benefit from the assistance of a trainer, whether physically present or online via teleconferencing. Whether the content is relatively basic or more specialized, a specialist trainer will give the opportunity to the trainees to make inquiries and ask for clarifications while the tutorial is taking place. However, given the maturity of the target audience, provision of ancillary online modules, as well as data and software for the manipulation of remote sensing data will play a more important role in the teaching process.

After providing an overview of the potential and applicability of remote sensing in various areas and disciplines, it should be left to each professional to decide how deep to delve in the specifics of remote sensing and its application to their area of interest. Professionals with a particular focus (group 4) will require high quality data and processing software to manipulate these data, as well as detailed explanation of the available image processing algorithms.

4.3 *Overall course structure and individual module design*

Having identified the needs and background knowledge of the target groups and outlining the content of the modules to be offered to each group, it is evident that there is some common ground and to an extent, some continuity between these modules. It is, therefore, possible to design a single course to be used by all audiences, with each target group having a different entry and exit point along the course sequence, depending on needs and acquired knowledge.

The sequence of the modules should progress from simple modules, to those containing more detailed and technical information regarding remote sensing and its applications (Figure 1). A simple overview of the applications of remote sensing would be an appropriate starting point for the course for students of all ages. Advanced students would proceed to the introduction to the electromagnetic radiation, the manner in which EMR interacts with matter and the spectral signatures of features on the Earth's surface. This module would be an appropriate point of entry for both groups of professionals in order to ensure the technical knowledge around EMR is provided. Subsequently, the groups of advanced students and both groups of professionals would proceed to the introduction of the currently available remote sensors and platforms and the basic image

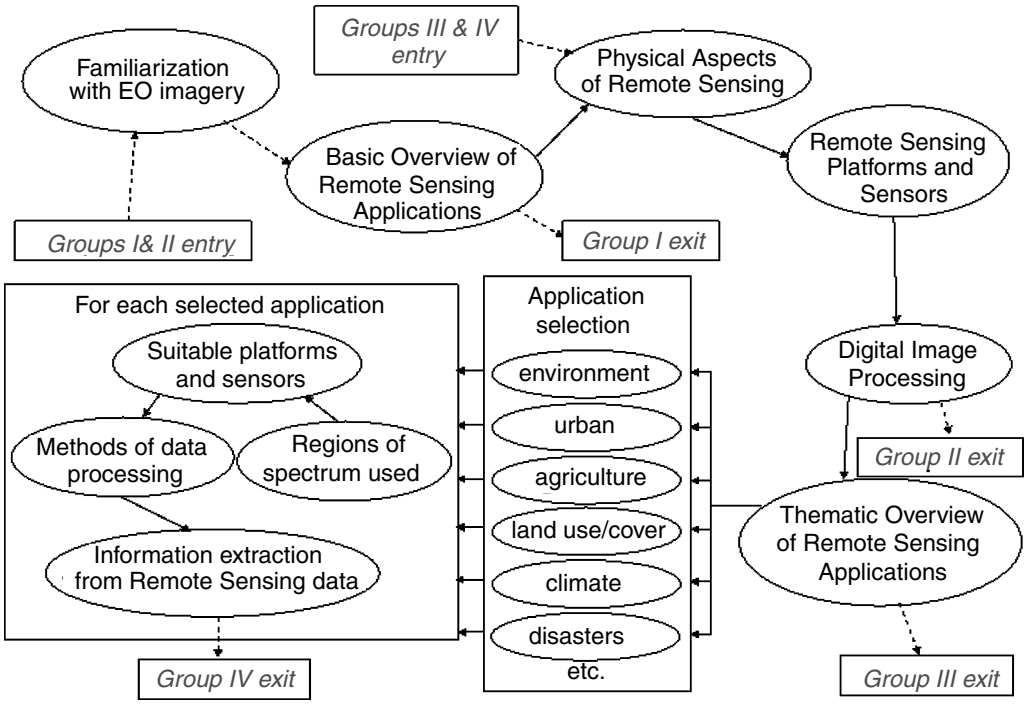

Figure 1. Proposed course layout and suggested entry and exit points for each group.

processing operations. At this point the course will end for the advanced secondary school students.

Both groups of professionals would progress to the next module, dealing with a more in-depth and technical overview of the applications of remote sensing. Detailed information regarding individual applications (environmental and natural resources management, ocean studies, climatology, meteorology, agriculture, land use/cover studies, geology, disaster monitoring, planning and urban applications, etc.) will be available, providing the audience with the choice of specific applications.

The next and final section of the course is aimed towards the specialized professionals, interested in a single or a small number of applications. Following a choice of application the audience will access a group of modules consisting of information on the sensors and platforms used to obtain the data, the methods of processing and manipulating these data, and the output information following these actions.

Each group, depending on its knowledge background and interests, would have the choice of accessing any or all sections. For example, students in the later part of secondary education (group 2) will be able to progress beyond the recommended exit point and learn more details about specific remote sensing applications. In addition, professionals with a general interest in remote sensing and its applications (group 3) could be intrigued by a specific application and would be able to learn more about the particular application.

5 DISCUSSION AND CONCLUSIONS

Remote sensing modules are available in various university courses, dealing with its application to the discipline the particular course is concerned with. However, modern European society needs to enhance its skills and competencies in every day working life. It would be beneficial to younger students to be exposed to remote sensing and be provided with general as well as specific information regarding its use and applications. In addition, some professionals, whose discipline is directly associated with remote sensing, are still unaware of its potential benefits. The proposed course in remote sensing and its applications aims to satisfy a broader audience of students and professionals.

Integration of remote sensing lessons in the existing school curriculum is the simplest way of approaching secondary school students. Such efforts have already been made in many countries (Hassenpflug *et al.* 1999). In most cases the lesson content had been adjusted to fit the requirements and capabilities of the audience. The proposed course covers a wide range of student ages and provides the flexibility to the audience of selecting which parts of the course to access. Even though the course would be available through the internet for use at the students own time, it is recommended that teacher supervision is available, to provide direction and explanations to the students. This will require the employment of teachers specialized in scientific disciplines and their education in remote sensing issues.

The modules aimed at secondary education students are primarily demonstrative in nature, with simple exercises that can be performed on relatively simple computer systems. On the other hand, the modules designed with a professional audience in mind will involve the use of large amounts of digital data and require the use of more powerful computer systems with access to sophisticated image processing software. Even though most European households own a computer with access to the internet, provision of sufficiently powerful computers should be made available on the seminar site to ensure that all interested parties have access to them. Certain types of image processing software and remote sensing imagery is available at a low cost or free of charge nowadays, and these would be useful for the online accessing of the course by those in possession of a computer system at home or work.

In addition to the use of lessons for high school students and seminars for professionals, the role of the media (newspapers, magazines, television) in the process of the educational diffusion of remote sensing should be considered. Structured series of television programs with a scientific content is already in place in many European countries (Freed, 1998) and some digital channels devoted entirely to learning (e.g. BBC Learning in the UK). This platform could be used to provide an additional source of information for the target groups this study is focusing on, as well as the general public. Articles in magazines and newspapers, could also contribute to raising the awareness and educating the general public in the matters of remote sensing applications.

Since this course is having a European-wide secondary education audience, it is of great importance to investigate the structure of secondary education throughout Europe. The entry and exit points for each country, region and even school need to be adjusted accordingly and make the module available in a number of European languages. Above

all the implementation of such an initiative postulates the European and national governmental agreement.

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