DISTANT LEARNING ON GEOSPATIAL INFORMATION SCIENCE AND TECHNOLOGY

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ABSTRACT

The course material to be developed for distant learning on Geospatial Information Science and Technology courses is analyzed and presented. An effort to develop elementary standards combining static material from existing scientific developments together with dynamic material from research developments and create an open system of learning is discussed and illustrated. The science guided technological aspects of the course are modulated into algorithms converted easily into software to obtain quick results thus having a better understanding of science. Emphasis is given thus to the software development, which facilitates both the scientific learning process and the understanding of the Systems from the inside. The broader meaning of education is examined to its philosophical bases in order to help faculty and students to use the course knowledge to improve quality and prosperity in life.

INTRODUCTION

The area of Geospatial Information Science and Technology (GISAT) has been grown rapidly for the past years involving many fields such as Photogrammetry, Remote Sensing, GIS, GPS, Cartography, Geography, Information Science together with almost unlimited application fields i. e. Resource Management, Planning, Environment, Water Resources, Climate and Global change etc. GISAT is actually a result of technology advances in computer science, space technology, data management, and communication technology. NASA, ESA, UMETSAT and several other space agencies from different countries are investing a lot to space technology and particularly to data acquisition of the earth' s environment. There are many orbiting satellites equipped with remote sensors producing a huge amount of data covering at various resolutions the entire earth. Cartographic data from various sources together with other information are gathered and integrated into GIS systems and are available for users in various applications. The application fields thus can take advantage of a wealth of reliable information derived through GISAT to work in their specialized region. The problem, However, is that the applications at the moment are very limited and part of this problem is the limited education and training regarding GISAT.

This paper intends to examine this problem make an in depth analysis, take advantage of communication technologies such as Internet to facilitate distant learning, and provide durable solutions of broader acceptance taking also into account of what is going to happen for the next generations. An important issue regarding GISAT is that someone may consider it just a set of tools. For example, GIS tools, remote sensing tools, photogrammetry tools. This does not mean, "there is a black box to do the job" (although in some cases this happens), instead there is a huge scientific background behind those tools and if someone does not have a basic knowledge feels threatened by such technology (Dahlberg R.E., and Jensen J.R., 1985). On the other hand scientific background on GISAT areas is necessary for any related research including the applications. The problem on education and training in the fields of GISAT is located firstly at the people in the applications. Those people do not have the time or perhaps the courage to start learning new things beyond the specialized field they serve where they maintain a quite high status within the scientific community using conventional data and methods. Secondly the fast evolution process in those technologies requires a constant training which makes it quite difficult for people to deal with. Thirdly University and Education Institution programs specialized on GISAT have difficulties to have faculty specialized at the same time in three different areas such as: Geospatial Science and Technology, Information Science and Technology, Related Applications. The industry on the other hand is more capable to attract such people and thus maintains a high contribution to the training, which is positive to a certain degree, but because of its nature it is limited by the industry' s specific interests and lacks of academic freedom.

Other matters which are discussed here involve the various levels of education training of people specialized on GISAT such as scientific level, professional level and technician level. Scientific level covers all scientific bases and the way to convert those bases into algorithms and software. Software development however, is important for both to understand science and to make GISAT systems useful for applications (Hatzopoulos J. N., 1997). Professional level requires as a minimum the scientific level plus experience and know how. Professionals are capable to do research and provide technical support to GISAT areas. Technicians may be limited to use the GISAT systems for black box operations (button pushers). Scientists and professionals in the applications who need to use GISAT methods and data must have a basic scientific background on GISAT to overcome the threat they feel from such systems (Dahlberg R.E., and Jensen J.R., 1985). Parallel to this, they must seek support from scientists and professionals specialized on GISAT. One major issue discussed, is the broader meaning of education such as healthy thought and how can be implemented to contribute on the quality and prosperity in life.

THE COURSE MODEL

Most distant learning and Internet tutorial GISAT courses at the moment cover good enough the scientific part (ASPRS, NCGISA, NASA, CAMFER, JARS). The technology part is either been ignored or partially covered (ISPRS, Joachim Höhle, Irina N. Sokolik). Other matters such as education with its substantial meaning of healthy thought are ignored and focus is only given to training. The proposed course model does an effort to put some elementary standards and also to integrate science and technology together with education into a balanced configuration shown in Fig. 1.
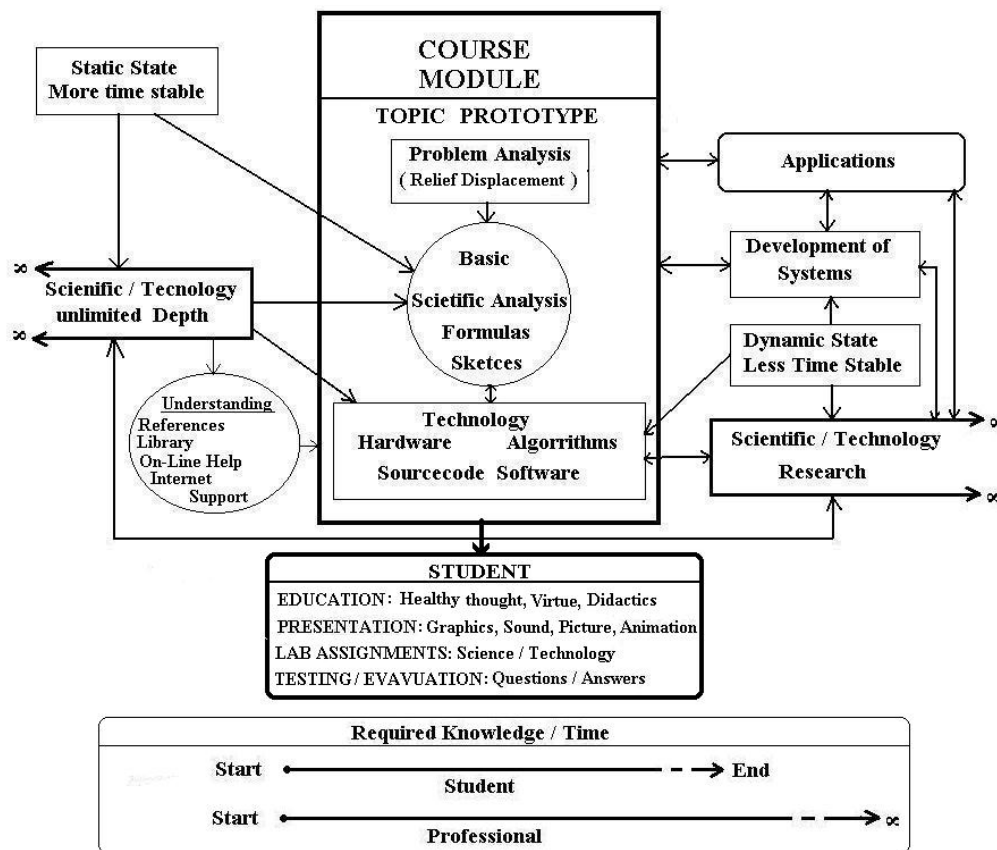

Figure 1. The course model.

There are two main parts shown in Fig. 1, the student part, and the course module part. The student according to Fig. 1, gets the course material first for education and then for training. The presentation of

the material is prepared by the instructor and then a group of experts does the final development making optimal use of all available means (multimedia, animation, sound etc.). Lab assignments are designed so that technology is playing a key role to understand science. Science itself may be boring, technology however is able through educational software to provide quick answers to complicated scientific problems and this creates motives for the student to study the scientific aspects of the problem (Hatzopoulos J. N., 1997). Student evaluation to obtain credit for the course is done by carefully prepared exams. Course evaluation shall take into consideration the difference between the judgment of the learning student and the judgment of the same person when becoming a professional. In this way, evaluation results can help for improvement of the course.

The course module is organized into chapters and each chapter is divided into topics. Each topic has a prototype composed of the part of problem analysis; the part of basic scientific analysis; and the technology part (see Figure 1). The part of basic scientific analysis, which is a more time stable part, is connected through links to an almost unlimited number of scientific sources and the student has the choice to select and study at the necessary depth. The technology part uses the scientific bases to develop appropriate educational software, which illustrates how existing systems work, and it proves that the scientific bases are correct. This part is more dynamic and less time stable. The technology part is very important particularly for next generations because there is a tendency for younger people to treat existing systems as black boxes. They do not have enough help if asking questions related to the software, and because they are generally discouraged to get involved with the inside structure of such systems they loose interest on the scientific part the system is based on. What is going to happen in the future? one may say that: "… at this time, humans put a lot of effort to develop knowledge and transfer it into the rocks, at a later time rocks will have knowledge while humans, …?". The question mark denotes that it is not exactly known what is going to happen. The technology part is connected through links to an almost unlimited number of research development, and software development sources and students have the choice to select, study and practice at the necessary depth.

The course module is connected to existing systems and some of them may require an appropriate license to run by the student. Important links to the course module are potential applications. A variety of application projects will enhance the usefulness of a GISAT course in a divergent manner. The more application projects exist, the more people from specialized applications will attend the course, and the more space technology and data will be useful.

In Figure 1 is shown the time a student needs to finish the course while time for a professional is open ended.

This course model as discussed above, gives emphasis to the educational software. This software must be composed of simple modules applied directly to the scientific aspects of the course topics. The software development process has been advanced over the last decade and continues its advancing course with increased speed. This helps on one hand the developer by providing an almost unlimited number of tools, although some times it creates confusion because of the proliferation of such tools and facilities. The object oriented software development at present is the dominant approach to most GISAT problems and helps to develop an application with reusable code thus minimizing the source code development. The software development for educational purposes in a GISAT course, as stated earlier, is important to test the scientific procedures and make sure they work thus creating motives to study science at a greater depth. Such software can be based on any programming processor. It must be clear that the purpose of such a course is not to train students on software development but to help them understand the scientific bases in the area of GISAT and the way existing systems function and work from the inside. An advanced course, however, oriented towards the applications must use professionally developed software.

THE COURSE DEVELOPMENT – AN EXAMPLE

The course development follows a standard way. A typical course outline for a basic remote sensing course for students of an Environmental Studies program is given bellow:

Basic Remote Sensing Course.
This course is intended to provide the basic background on science and technology in Remote Sensing for students of an Environmental Studies program, as for example, at the University of Aegean in order to apply such knowledge for Environmental application projects including:
  (a) Ecosystem management (ecotones, biodiversity, nature conservation, wetlands, climate change, habitat, …),

(b) Environmental Engineering (Atmospheric pollution, liquid and solid wastes, water quality, water resources assessment, water shed management, hydrology, ecotoxicology, site selection, …)

(c) Environmental Planning (land use, land cover, coastal areas, urban areas, industrial areas, agriculture, tourism, risk assessment and management, natural disasters, …).

This course follows the standards developed earlier (see Figure 1) and uses the scientific analysis as an aid to prepare the necessary technology with the student being involved on developing algorithms and educational software. It is necessary to provide existing educational software in a source code form developed by the instructor so that students can use it, or, develop their own. Existing source code is necessary so that students can run it or modify it to obtain quick results, and understand the function of the system from the inside. There is however an advanced course dealing with environmental applications using commercial software systems. The course outline is as follows:

Course Name: **Basic Remote Sensing**
Course Level: **Sophomore**
Prerequisites: **Calculus, Visual Basic**
Grading: **Lab Assignments 30%. Exams 70%**
Course Chapters:
1. Introduction
2. Fundamentals of Remote Sensing
3. Sensors and Platforms
4. Remote Sensing Systems
5. Data used in Remote Sensing
6. Image Interpretation
7. Digital Imagery
8. Image Processing Systems
9. Image Correction, Georeferecing & Enhancement
10. Image Classification
11. Image Fusion from Multiple Sources of Data
12. Remote Sensing and Geographic Information System (GIS)

Focus will be given in chapter 9, which has the following topics:
9.1 Geometric Correction, Map Projections, Resampling
9.2 Atmospheric Correction
9.3 Other Corrections
9.4 Image Enhancement: Radiometric Correction
9.5 Image Enhancement: Density slicing
9.6 Image Enhancement: Principal component analysis
9.7 Image Enhancement: Spatial filtering
9.8 Image Enhancement: Texture analysis
9.9 Image Enhancement: Image correlation

THE COURSE TOPIC DEVELOPMENT – AN EXAMPLE

Detail material according to the course model (see Figure 1: Topic Prototype) will be given for the topic 9. 4 Image Enhancement: Radiometric Correction.

Problem Analysis
An image is composed of pixel values f(x, y), where x is the column and y is the row in the image, f is the pixel value taken from a set of integer values $(0, 1, 2, …, 2^n)$ which are called Digital Numbers or simply DN. The exponent n is also integer (n = 1, 2, 3, …) and denotes the dynamic range in bits of pixel values. An original image usually is composed of DNs which occupy the left part of the set of values thus being smaller than higher values in the set. In Figure 2a is shown an original image of six rows by three columns having a dynamic range of 3 bits (n = 3). Although the set of the DNs is from 0 to 7, only the numbers from 0 to 4 are shown in the image. The frequency of occurrence of those DN values is shown in Figure 2b by the corresponding histogram of the image. If the image shown in Fig. 2a is to be displayed in a computer display only the 5 out of 8 gray scale values will be shown thus limiting the quality of the image. Radiometric enhancement improves the quality of the displayed image by transforming the set of DNs to occupy most of the dynamic range. If the original set of numbers is $R_i(i = 1, 2, …, 2^n)$, the transformed set of numbers is $S_i(i = 1, 2, …, 2^n)$. There are several ways to do such a transformation by using:

(a) Empirical values in a form of Look Up Table (LUT),
(b) a function g so that S = g(R),
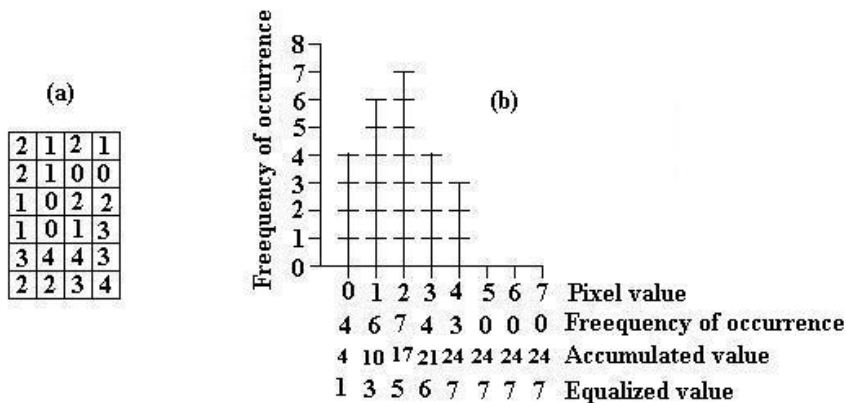(c) equal probability for all values in the dynamic range to be displayed.

Figure 2. Original image (a), and its histogram (b).

Radiometric enhancement maintains the original pixel values and makes the transformation only for display purposes. The result of all transformed values is a LUT with a total of 2^n values. Radiometric enhancement could happen to the entire image or to any part of the image called Area of Interest (AOI).

Basic Scientific Analysis

The term image quality has two parts, the one deal with the displayed image and the way human visual perception mechanism works (Hubel, D., 1987), and the other deals with specific information on the image to be retrieved through radiometric enhancement. The later requires explanation about localities and regions in the histogram of the image with appropriate references.

All transformations for radiometric enhancement deal with the creation of a LUT so that original pixel values R_i are transformed to display values S_i, the transformation rule is either empirical, functional, or probabilistic. Transformation to provide all available for the display gray tones with equal probability is called histogram equalization. The transformation formula is given as follows:

$$S_i = (N-1)P_i / M \qquad (1)$$

Where $N = 2^n$, n is the dynamic range, M is the total number of pixels in the image, and P_i are the accumulated histogram frequency values as shown in Figure 2b. The LUT values S_i are computed
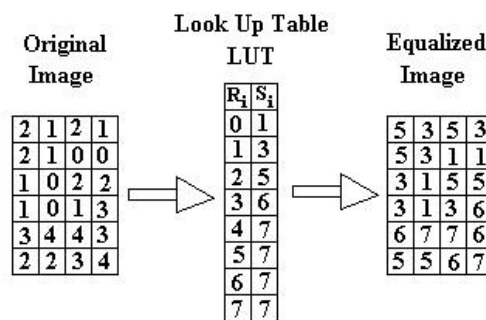

Figure 3. LUT for histogram equalization, R_i is the original pixel value, S_i is the transformed pixel value for histogram equalization (see also Fig. 2b and Eq. 1).

using Equation 1, see also Figure 2b and Figure 3. Applying the LUT values of Figure 3 to the original image, the equalized image is created. It must be noted that the equalized image covers a wider range of values within the dynamic range as shown in Fig. 4. Functional transformation has the form $S_i = g(R_i)$, where R_i are the original pixel values and S_i are the transformed values. The transformation function g could be of any desirable function. The simplest function has a linear form as follows:

$$S = aR + b \qquad (2)$$

As shown in Figure 5 this linear function can be defined by using two points P_1 and P_2 defined by the
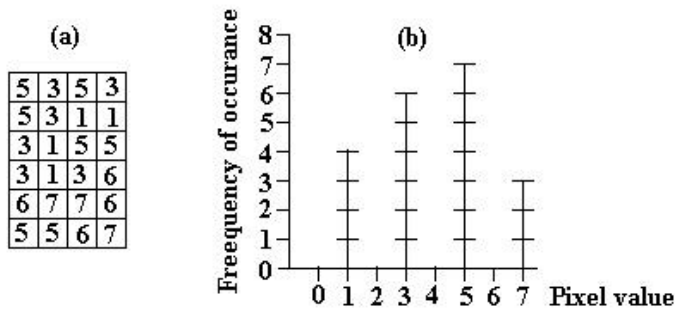

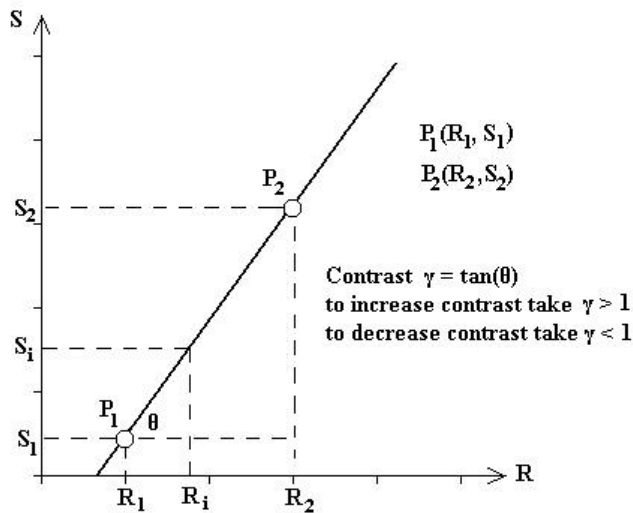**Figure 4.** Equalized image (a), and its histogram (b).

Figure 5. Histogram stretching

coordinates $P_1(R_1, S_1)$, $P_2(R_2, S_2)$ so that given a value R_i then a transformed value S_i can be computed as follows:

$$\frac{R_2 - R_1}{S_2 - S_1} = \frac{R_i - R_1}{S_i - S_1} \quad \text{or} \quad S_i = \frac{S_1(R_2 - R_1) + (S_2 - S_1)(R_i - R_1)}{R_2 - R_1} \quad (3)$$

The slope of the line shown in Figure 5 known as gamma, represents the contrast stretching and if gamma is greater than 1 then the contrast of the transformed values increases as compared to the contrast of the original values. If gamma is less than 1 then the contrast of the transformed values
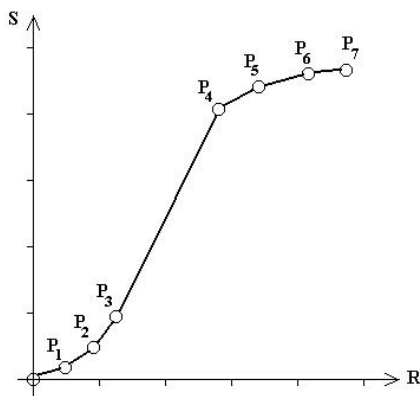

Figure 6. A transformation function g represented by a number of line segments defined by seven points $P_1(R_1, S_1)$, $P_2(R_2, S_2)$, ..., $P_7(R_7, S_7)$

decreases as compared to the contrast of the original values. It is important to understand that any transformation function g can be approximated by a finite number of sequential linear segments. This is illustrated in Figure 6 where a curve similar to the characteristic curve of a film is approximated by a small number of line segments. For each line segment the S_i values are computed using Eq. 3.

Technology analysis

The scientific aspects are used as a guide to produce corresponding algorithms and then materialize such algorithms into programming code, i. e. Visual Basic. Radiometric enhancement is a part of an image processor system as shown in Fig. 7 and has two components: (a) Compute Histogram and (b) Compute Stretching.
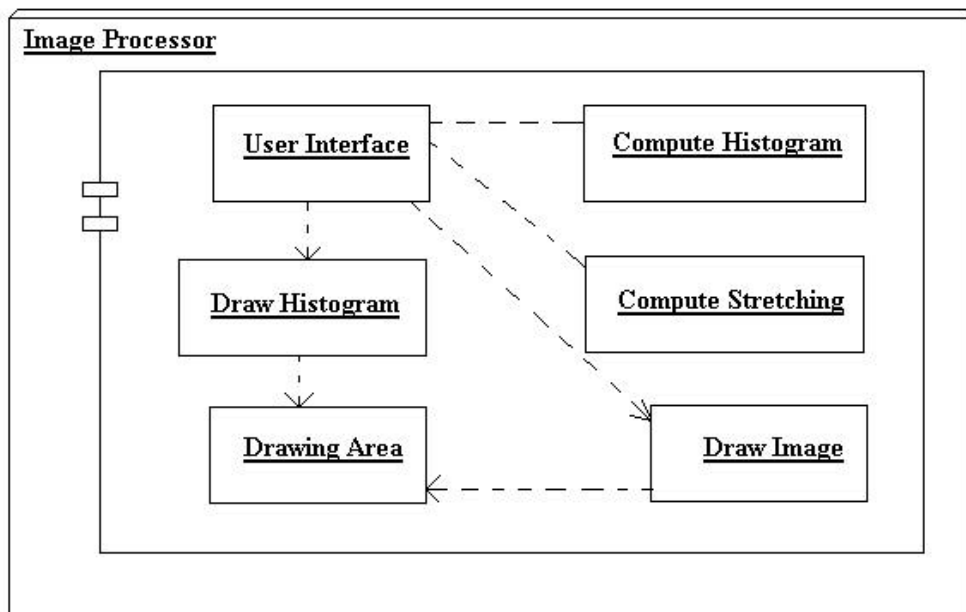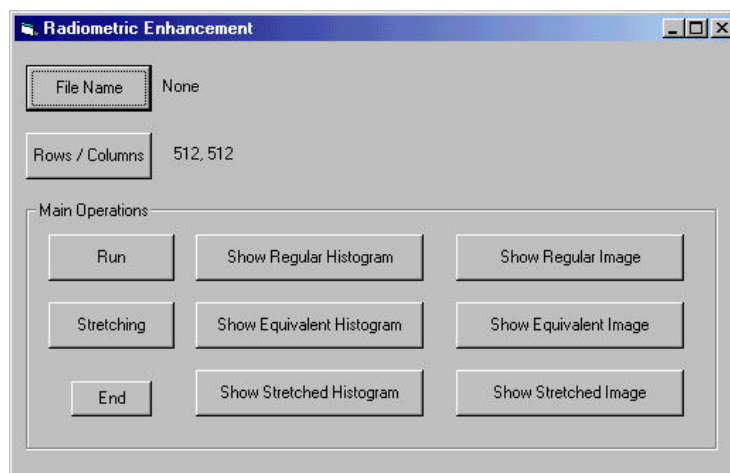

Figure 7. Component diagram of an image processor

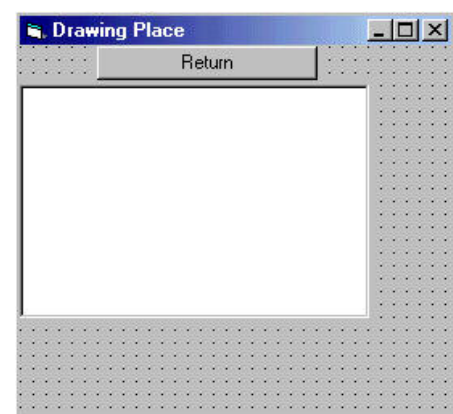**Figure 8**. The User Interface component   **Figure 9**. The drawing area.

An educational software is important to have all six components in order to visualize all processing operations. The **User Interface** component may be composed of a set of command buttons and have a form as shown in Figure 8. The **Drawing area** component could be a Picture Box with a return command button as shown in Figure 9.

The algorithm of the **Compute Histogram** component does the following tasks:
1. Opens the image file
2. Reads from the image file all bytes one by one, which curry the 8-bit pixel values and accumulates the frequency values for the regular histogram.
3. Computes the accumulated values as shown in Figure 2b, and based on those values computes the LUT values for histogram equalization using Equation 1 (see also Figure 3).
4. Closes the image file.

This algorithm is translated into Visual Basic code through a Public Sub called **Histogr** and is available to the students.

The algorithm of the **Compute Stretching** component does the following tasks:
1. Reads all values R_i, S_i, of the stretching nodes (node coordinates R_i, S_i).
2. Transforms all R_i values into S_i values using Equation 3 and based on those values computes the LUT values for histogram stretching.

This algorithm is translated into Visual Basic code through a Public Sub called **Stretch** and is available to the students.

LAB ASSIGNMENTS

Lab assignments for basic courses must use technology based on educational software to facilitate both scientific learning process and understanding of systems from the inside. Advanced courses, however, must use professional software to facilitate remote sensing applications. The image processor with its components discussed above, provides support for a variety of lab assignments. Such software is portable and easy to download (EXE module is of 36 Kb while the entire source code is 16 Kb). Lab assignments could include problems related to the system or problems related to the scientific aspects of the particular topic. System assignments could include: i. e. given certain components, it is asked to create a specific system by developing the user interface part of it, or, given a part of the source code to develop a step by step flowchart. Such assignments are within the student potential if they have completed a computer programming course. Problems related to the scientific aspects are given bellow:

Lab assignment 1.
Given raw image data of channels 1, 2, and 3 of NOAA – 14 AVHRR reduced to 8-bit:
(a) show the regular histogram and the regular image for each channel,
(b) show the equalized histogram and the equalized image for each channel,
(c) based on your observations stretch the image of a selected channel to show the clouds.

Solution.
(a) Regular Images and corresponding histograms are shown in Figure10.
(b) Equalized histograms and corresponding images are shown in Figure 11.
Channels one and two have most DN values being between 0 and about 60 and therefore there is a significant improvement from the image enhancement while channel 3 is spread out through most of the 8-bit range thus having some quality in the original image.
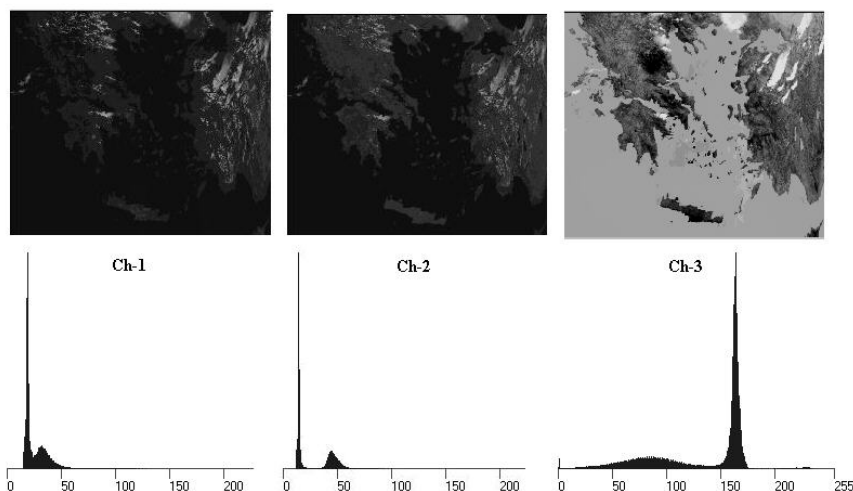

Figure 10. Raw image data of channels 1, 2, 3, of NOAA 14 AVHRR taken on May 26, 1998 by a receiving station located at the RSLUA of the University of the Aegean.
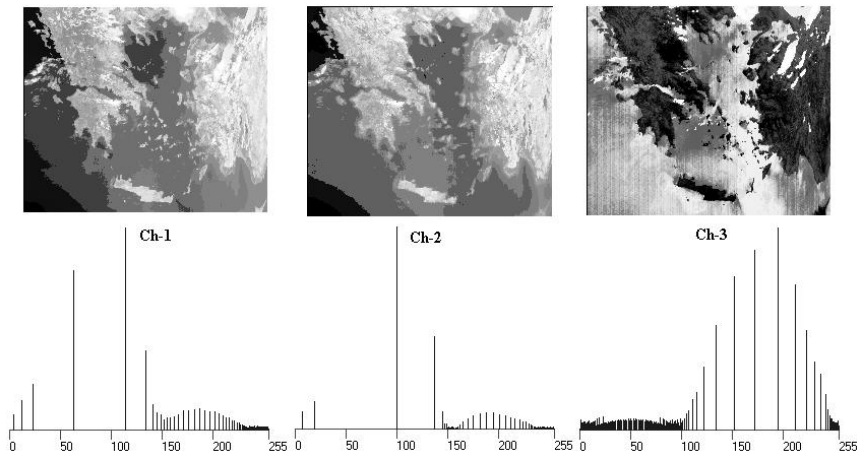
Figure 11. Enhanced images of Fig. 10 (Equalized Histogram).

A careful look at all images concludes that the image from Ch-1 shows most of the clouds. Since clouds appear with highlighted tones, such histogram values seem to be between DN 50 and 65. By stretching those two points with transformation coordinates (R1 = 50, S1 =10), (R2 = 65, S2 = 230) then the image in Figure 12 shows most of the clouds. It must be noted that such estimates of clouds are not very precise, there are however more precise algorithms for cloud mapping which may use all 5 AVHRR channels.
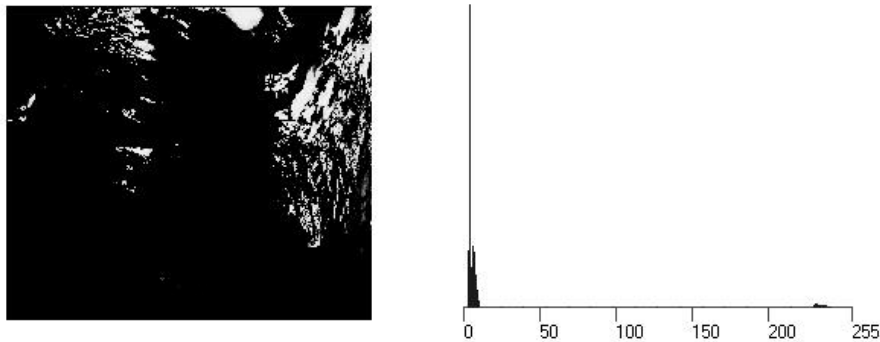

Figure 12. Stretched image between DN 50 and DN 65 of original image to reveal clouds.

EDUCATION AND LEARNING

The effort to produce material for GISAT distant learning contributes to quality and prosperity of life of the potential student under one condition (Hatzopoulos, 2004) that the knowledge acquired through the course will be properly used. The wise use of this knowledge has to do with the education of the student. Education, according to Plato (*The Republic*), is responsible to develop a balanced and healthy thought "…if the body is sick needs medical attention, if the thought is sick needs education". According to Plato healthy thought exists if the Logic state of the thought keeps check and balance between the two other states of the thought which are the desire and the anger. Plato also says: "as the coachman of a wagon pulled up by a blind horse and a crazy horse has to keep control and balance over the two horses to move on the correct way the same way control and balance must be kept by the logic state of the thought over desire state and anger state in order to have a healthy thought". Aristotle (*The Nikomacheian Ethics*) defines as correct way the wagon must follows as virtue or arete. Virtue according to Aristotle is a mid way between two extreme positions, or badness. Aristotle gives the following example: "…virtue "brave" lays in the midway between the coward and the provocative and the coward will see the brave as provocative while the provocative will see the brave as coward". Similarly virtue "economy" is in the middle between the stinginess and the overspending. Aristotle accepts that a person of virtue is the one who tries to follow the way of virtue (giving a chance to

anybody at any time to follow the way of virtue), and also defines justice as the higher virtue, which includes all other virtues. Based on these ideas, ten fundamental principles for education have been proposed by Hatzopoulos 2004, to be adopted by all course offering Institutions to have a typical coverage against the wrong use of knowledge. The effort to follow such principles helps for the right use of knowledge thus contributing to quality and prosperity of life. These principles are as follows:

1. Education is the development of healthy thought to those who follow the way of virtue.
2. Training is the development of healthy thought on a specific field (i. e. the environment) to those who follow the way of virtue.
3. Thought is one of the three states of human mind before one does or acts upon something. These states are: (a) logic, (b) desire and (c) anger. Thought designates all actions performed by a person at present and future and always precedes the action.
4. Healthy thought exists when the logic state of human mind controls over and balances the other two states of the mind, namely desire and anger.
5. Healthy action exists when it is done under healthy state of mind and follows the way of virtue.
6. Virtue is the action of a person who follows the midway between two extreme positions or badness. Responsibility, for example, is a virtue and is between irresponsibility and over-responsibility (fear for not being responsible).
7. The person of virtue is the one who tries to follow the way of virtue; s/he is characterized by the effort to maintain the way of virtue (midway).
8. An action of virtue is the effort of an action to maintain the way of virtue (midway).
9. Justice is the supreme virtue and incorporates all virtues.
10. Democratic rules are those procedures which determine the midway of virtue.

Those basic definitions (Education, states of the thought, and the way healthy thought guides all actions being the virtue) are also accepted by European educators (Jaeger Werner, 1945) and must be officially adopted by the education systems.

CONCLUSIONS

Distant learning GISAT courses as presented here, integrate all available achievements from science and technology together with communication facilities and computer and information sciences into a complete course model. Such a course has the advantage to attract highly qualified GISAT people to produce basic material together with a team of experts from computer and information sciences and from education and multimedia presentation to provide a more efficient presentation such as animation, graphics, sound, virtual reality etc. Such material is important to be carefully prepared following similar to proposed specifications to help people in the field of applications to understand better GISAT and increase the use of such GISAT for more operational applications. Important issues related to education and training as well as definitions such as healthy thought and virtue have been discussed and clarified. It is suggested that such clarifications must be officially adopted by the education system since Plato's and Aristotle ideas are diachronic with wider acceptance.

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