# Hyper spectral Perception of Roofing Materials in Relation to History

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***ABSTRACT-*** *This paper grants the results of a research movement aimed at studying urban areas by means of at all sensed hyperspectral data developed over the city of Rome. The arrangement of remotely sensed images allowed us to identify dissimilar spectral classes referred to materials used for construction roofs and to deduce contemplations on how the use of building techniques and materials has evolved in space and time, or the architectural composition of building volume. In individual, the classification shows how roof covers reflect a definite epoch and how the construction style, combined over the centuries, granted the privilege to use local materials until the 19th century. From the 19th century forwards, there is a period when unapproved buildings and urbanization were rampant, with an undiscerning and chaotic use of materials like bituminous surfaces, crenelated iron roofing sheets and so on.*

## I. INTRODUCTION

The images taken by remote sensing over the city permissible us to perceive the city from above in a way that we have never seen before, to discover elapsed corners of the urban landscape, where historical squares, domes of minsters, and in particular building roofs, are malformed into objects without any secret which can be easily acknowledged on the basis of their geometry, colors and materials. In this way, it donates to the conservation of the artistic and cultural patrimony in the antique centers of the cities. Remote sensing characterizes a major, though still under-used, source of urban material by providing spatially dependable coverage of large areas with both high spatial detail and temporal frequency, counting historical time series. With enlargedobtainability and improved quality of multispectral and multi-temporal remote sensing data as well as new systematic techniques, it is now possible to monitor and scrutinize urban expansion and land use change in a timely and cost effective way.

However, there are some procedural challenges in recovering accurate evidence of urban expansion and land use changes. A major struggle in urban remote sensing analysis is caused by the high heterogeneity and complication of the urban atmosphere in terms of its spatial and spectral characteristics. A successful employment of remote sensing requires adequate consideration and understanding of these specific urban landscape appearances in order to fully explore the competences and limitation of remote sensing data and to appraise appropriate image analysis techniques. Cowen and Jensen outlined the affiliationamong selected urban/suburban characteristics and the remote sensing determinations required to deliver such adequate information. Among these issues, the most imperative technical concern has been the pursuit of finer spatial tenacities of image pixels. It was recommended that remote sensing data with a spatial resolution of 0.5–10 m are required to regulate adequately the high frequency detail which characterizes the urban.

To this aim, the Daedalus AA5000 MIVIS apparatus, acquired by the Italian National Research Council (CNR) was used. MIVIS is a modular perusing system constituted by 102 spectral channels that use autonomous optical sensors instantaneously sampled and recorded within the interval comprised among 0.433 and 12.70$\mu m$. This instrument, with 4 spectrometers considered to collect radiation from the earth's surface in the Visible, Near-IR, SWIR and Thermal-IR, represents a second generation imaging spectrometer developed for its use in conservational remote sensing studies across a broad spectrum of scientific disciplines.

In addition to a very high spectral resolution, MIVIS also offers a high spatial resolution, with a pixel of 3m x 3m. This allows a comprehensive analysis when urban objects are to be acknowledged and, in particular, when casing materials such as tiles and bricks, marble materials, asphalt, lead, copper, asbestos cement, vegetated areas, bare soils are complicated. All these appearances make this instrument extraordinarily interesting for the study of entropized areas, supporting an analysis never carried out so far at such an operative level. In this respect, the results gained in the classification of hyperspectral data have shown the great potentialities of these tools applied to urban areas, complex situations with a high degree of fragmentation On the basis of these considerations, this paper presents a research activity over the central area of the city of Rome, to differentiate and quantify urban foundations and materials by means of tenuously sensed MIVIS data, in order to deduce replications about how the use of building techniques and materials has embellished the growth of the city.

## II. STUDY AREA

The site taken into consideration for this study belongs to the territory of the city of Rome. The test area covers a north-south transect of km by 147.12 km2 along the Tiber river (see Figure 1).

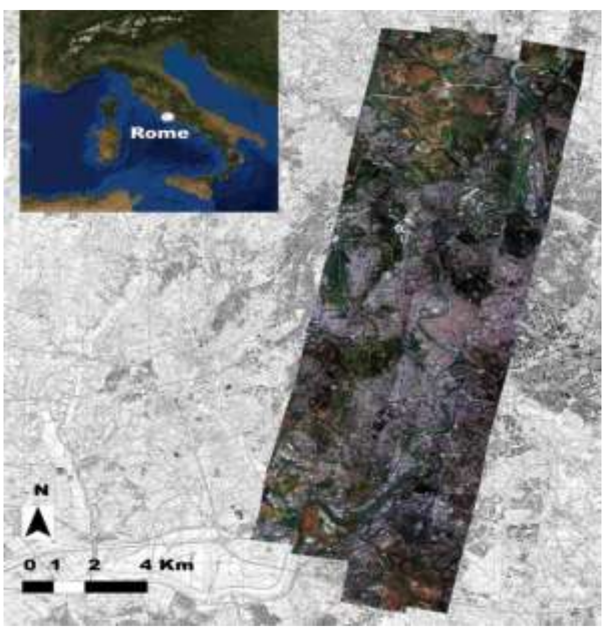


Fig 1. Territorial framework of the study area

## III. MATERIALS AND METHODS

The MIVIS data were standardized according to the procedures pronounced by Bianchi et. al. [1996]. Not having reflectance quantities to the ground and information on the classification of the column of air between the sensor and the ground at our disposal, the correction method known as IARR (International Average Relative Reflectance) defined in, was used. It comprises in dividing the happiness spectrum of each pixel of the flight line by the average spectrum of the whole scene. This procedure is a variance of the socalled criterion known as "flat field calibration", which almost removes solar irradiance, atmospheric absorption, scattering effects and any other residual noise from the instrument. Data were classified in order to obtain a thematic map to which is associated, besides the spatial information, semantic information which specify the socalled class. The data, radio metrically corrected, were confidential using the Spectral Angle Mapper (SAM) approach. It is a computerized method which permits rapid organization and recording of the spectral similarity of image spectra to reference spectra. The SAM algorithm executed in ENVI software takes as input a number of training classesor reference spectra from ASCII files, specific ROIs (Regions of Interest), or spectral libraries. As far as this study is disturbed, the input spectra were extracted from ROIs exactly identified in the MIVIS image. Inside each ROI, areas having dissimilar morphological characteristics were selected: flat surfaces or ones with changed exposure slopes, to best characterize the variability of the area taken into deliberation.

## IV. DATA ANALYSIS AND DISCUSSION

The figure 2 shows the results of the organization of the MIVIS image mentioned to a study area in 9 spectral classes, accomplished by the Spectral Angle Mapper (SAM). From aninitial visual analysis, defined by Foody as the first and the most imperative step of accuracy assessment of methodology, a good discrimination of the ground surfaces can be observed which shows the good potential of the MIVIS data for the discernment of dissimilar surfaces. Moreover, the map providesmotivating information about the extension and the direction of the urban development, inparticular the expansion of covering materials in time and space. The classification results were then evaluated by calculating the matrix of confusion designed to verify or "to test" the presentations of the classifier, obtained from ROIs accurately identified in the scene, combined with the visual analysis of additive synthesis in RGB (Red, Green, Blue).

The values of the main diagonal of the misperception matrix represent the examples of arrangementamong the arrangement and ground truth class, whereas the values found off the diagonal epitomize pixels classified inaccurately. Additionally, two kinds of errors can be calculated: errors of Omission and errors of Commission. The first ones are shown in the columns of the confusion matrix. They characterize pixels that belong to the ground truth class but the classification technique has failed to classify them into the proper class. The second ones are shown in the rows of the confusion matrix. They epitomize pixels that belong to another class and that are characterized as belonging to the class of interest.

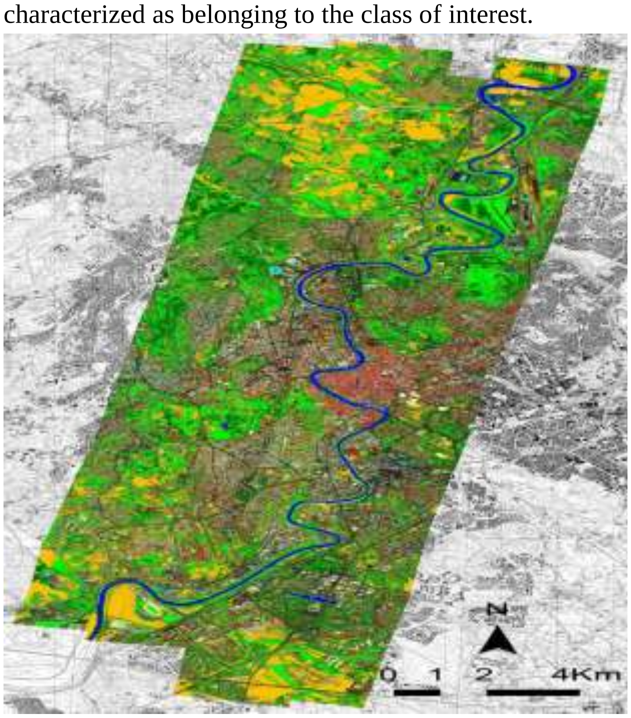


Fig 2. Classification of remotely sensed MIVIS images
acquired from an altitude of m 1.500

These materials are mixed with consistent synthetic products as far as road are concerned bitumen is instead blended with inert matters as a binding compound. As a concern, where the road cover is in good condition the asphalt emerges and the above classes tend to mingle spectrally, where instead the inert matter emerges due to wear the two classes tend to separate. Consequently the classification accuracy of74, 82% of the class *Roads* reveals the ethereal predominance of the compound "inert matters" over the compound "bitumen" so indicating the asphalt's state of wear of the road cover in the area investigated. *Tiles and bricks (94, 38%)* class tends to be confused with that of *Bare soils (96, 97%)* mainly in the nearest neighbor areas characterized by the presence of large areas of clayey soils. Similarly significant is the spectral confusion be-tween Travertine and grits (94,76%) and Metallic surfaces (sheets) (77,50%)classes, due to the lead rust which tends to become similar to travertines and the other light construction stones.

The cover gives the impressions of a no man's land, a space of fortuitousness andrejection, which is observable in the chaotic use of material: *Bituminous surfaces (11,13%), Metallic surfaces (1,30%).* Finally, at the top and bottom of the arrangement MIVIS, away from the city center, where the city becomes less densely built, dominated by the main *Roads (13,24%)* linking the city with the geography.The first strong inscription of nature is that of the Tiber river, *Water bodies (1,72%)*. With its winding loops, the river has separated the scene into two sections. It is absolutely the most defined shape, made up of a single cluster of pixel, confidential with an accuracy which is equal to 97,96%.

At the center of the image is the Tiber Island (Insula Tiberius) which lies in the middle of Tiber river: natural ford, it was essential to the erection of perpetual installations on the surrounding heights of peoples (the Etruscans and the Sabines) who inhabited along the Tiber river in the 8th century B.C [23] (see Figure 3).
It was completely built in Travertine and the Island profile suggested arranging of the external perimeter in shape of war ship, with the defensesprepared for the moorings and with an obelisk as the main tree. It is associated to the left and right banks of the Tiber River through Fabricio and Cestio bridges whose structure dates back to 62 B.C.

Figure 3. Tiber Island

Additionally, the organization highlights a large number of *Lawns* and *Bare soils*. These are grounds left free of creations, the last remnants of the hybrid atmosphere - concurrently agricultural and urban, city married to campagna - that was Rome. New roof covers made of light, opaque or transparent materials are now available on the market. These materials offer occasionally impressive decorative solutions, such as corrugated iron roofing sheets, fibrocement sheetsand polycarbonate or textile fibres. Though, the increasing attention to conservational sustainability issues has led to use roof covers made of natural or environmentally friendly materials.

## V. CONCLUSIONS

The MIVIS data assimilated over the city of Rome allowed us to determine, in an original and innovative manner, how it was possible to describe and quantify the roofing surfaces and to deduce contemplations on the aerial view of the city, Especially, attention was focused on how the use of the procedures of building and roofing materials has evolved in space and time. Dissimilar with the old city, showing up as homogeneous and continuous in terms of roofing materials and styles, is a more random city. The pitch of brick-tile roofs, which has down the century'scategorized construction methods and is still used today, tends to merge into the landscapewhich now resembles an obstacle course.

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