Potential of space imagery in mapping application

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New trends of mapping from high resolution remote sensing imagery present the importance and the necessity of using them in many applications such as topographic and thematic mapping instead of traditional methods. Remote sensing imagery can be classified into many types and each type serves a specific scientific application. Remote sensing imagery classification depends on many factors such as band range, image acquisition technique, image resolution and image processing level. This paper studies the classification of remote sensing imagery and their capability to produce topographic and thematic maps with a good quality. Moreover, a guide software is proposed and outlined to help the user in selecting the appropriate space imagery for the respective application.

إنّ عمل الخرائط بواسطة صور الأقمار الصناعيه ذات الدقه العاليه يُعتبر من الإتجاهات الحديثه ذات المميزات العديده التي تُعطى تلك الأهميه خاصة من المُهتمين لإستخدامها في عمل الخرائط المساحيه بدلاً من الطرق التقليدية. تُصنف صور الإستشعار عن بُعد إلى عدة أنواع بحيث أن كل نوع يخدم تطبيق مُعين وهذا التصنيف يعتمد على عدة عوامل مثل قيمة ونوع المجال الطيفي، طريقة تجميع الصوره، درجة وضوح معالم الصوره و درجة معالجة الصوره. هذا البحث مُكرس لدراسة تصنيف صور الأقمار الصناعيه ومدى مقدرة هذه الصور على إنتاج الخرائط الطبوغرافيه وخرائط المجموعات ذات الجوده العاليه من حيث الدقه ومقياس الرسم ودرجة وضوح معالم الصوره وتمييزها. هذا بالإضافه إلى إقتراح بعمل برنامج يُساعد مُستخدم صور الأقمار الصناعيه إلى إختيار الصوره المُناسبه للمشروع المُحدد وفق معايير مُحدده من قبل المُستخدم.

Keywords: Remote sensing, Space imagery classification, Mapping

1. Introduction

The evolution of remote sensing imagery world markets returns to their merits against traditional images. Using remote sensing imagery for topographic and thematic mapping is apparent and rapidly increased.

In order to produce a map from space imagery, it is necessary to keep in mind all the mapping requirements defined by the user. For example, the information content, the map scale and the required accuracy.

Classification of remote sensing imagery is very important step for determination the most appropriate image for the required project. As a result, guide software helps space imagery users to select the suitable image for the desired project is recommended; taking into consideration the parameters, models and space images databases that effect in this software.

2. Merits of mapping from space imagery

Space imagery is often the most practical way to acquire useful geographic information instead of traditional methods with many significant advantages, for instance [1].

- Nearly, all space imagery is acquired digitally. So, there is no need for expensive data conversion, scanning or digitizing. Space imagery can be processed, manipulated and enhanced to extract subtle details that other sources miss.
- Remote sensing satellite can map a vast forest or an entire city in a short time comparing to the photogrammetry technique.
- Remote sensing imagery is less expensive than aerial photography. The cost of a raw image averages to below $1/sq.km except the initial expenses.
- Satellites are not limited by political or geographical boundaries and not restricted for a specific region.
- Remote sensing imagery is the most up-to-date map available and it could be in hands in few days after it is acquired.
- Satellite with adjustable viewing geometry can acquire stereo images. Therefore, Three-Dimensional modeling could be created and it is most used for representing the terrain topography.

As a result, the launching of many commercial remote sensing satellites is thoroughly accelerated and the evolution of world space imagery markets is rapidly increased.

3. Applications of topographic and thematic mapping

Topographic maps show the characteristics of the earth surface. These characteristics include relief, natural features and man-made features. Topographic mapping is based on the use of remotely sensed imagery. It provides the basic information for maps construction and the coordinate information about terrain features, which is generated during mapping [8].

The creation of topographic maps is considered a rich source of data that could be used in many scientific and civil engineering projects. Such a map is essential in the layout of an urban planning, the location of highway or railway, the design of irrigation or drainage system, the development of hydroelectric power and in the telecommunication field.

Thematic maps focus on special topics superimposed on a base map. Thematic maps are considered a basic source of extraction information. Their importance continues, and possibly has been enhanced by the explosion growth in the use Geographic Information Systems (GIS) [9]. Thematic maps sometimes called the categorical maps and could be considered as cadastral maps in limited applications. They are used in many scientific applications for example, vegetation, minerals exploration, identification and classification of soil units, geology and forestry.

4. Data requirements for mapping operation

Mapping from space imagery consists of three main factors, information content, planimetric accuracy and elevation accuracy.

The information content of a topographic map compiled through remotely sensed data is provided by the ground resolution of the images, expressed in meters/line pair for photographic camera systems or as meters/pixel for electro-optical systems [2].

The planimetric accuracy requirements for topographic mapping are not uniform throughout the world. Examination of the standards for the map scale 1:50,000 from several countries have shown a planimetric accuracy requirement for well-defined features, represented as a standard error, ranging between ± 0.2 and ± 0.7 mm [3].

Elevation accuracy is required to determine the suitable contour interval for topographic maps. It is important to note that, a given contour interval is not associated with a fixed scale. A 1:50,000 scale maps for example, may have 5, 10, or 20m contours depending on the standard error of the elevation, the complexity of the terrain represented, and the purpose of the map [4].

5. Remote sensing imagery classification

Remote sensing imagery can be classified into many types. Each type serves a specific scientific application. The most important type of remote sensing imagery is that used for topographic and thematic mapping. Remote sensing imagery for mapping could be classified according to many criteria, and some of these criteria are illustrated in fig. 1.

In this paper six satellite systems are considered and their respective image products are classified according to the previously mentioned criteria. Table 1 summarizes this classification.

6. Digital image analysis for mapping

In order to produce a map from space imagery, it is necessary to keep in mind all the mapping requirements defined by the user. For example, the information content, the map scale and the required accuracy. Furthermore, the availability of the basic raw data from the satellite and the ancillary information from the ground should be taken in account. These data are, Ground Control Points (GCPs), Digital Elevation Models (DEMs), Interior orientation parameters, Exterior orientation parameters and map projection type.

Processing of data to produce a map means correcting all the errors propagated during the whole procedure. According to the user demands, the types of errors to be overcome during manipulation of data specify the degree of the processing level.

Recently, digital analysis of space imagery is widely applied in many aspects with the availability of images in a digital form. The idealized sequence for a typical digital analysis, fig. 2, could be expressed by many steps starting with the input of digital data, preprocessing level, and feature extraction to reach the classification step and finally reaching the classification accuracy assessment to get the output result in the form of maps (images), reports or data [5].

7. Sources of space imagery for mapping purposes

During the last few decades, many remote sensing satellite systems have been launched to serve different applications such as, meteorology, resource management and cartography. The launch of the new generation of very high resolution commercial satellites began in early 1998 such as IKONOS 2, which started a new era of space imaging for earth observations. It is conceivable that about 24 commercial remote sensing satellites should be operated by the end of 2003.

Remote sensing satellite systems can be classified into two main categories, active systems and passive systems. As this paper concern in mapping from remote sensing imagery, the following satellites are investigated, LANDSAT, System Pour l' Observation de la Terre (SPOT), Indian Remote Sensing System (IRS), Russian Space Cameras (SPIN 2), Space Imaging Inc. (IKONOS) and RADARSAT. Table 2 summarizes the orbital characteristics of these systems.

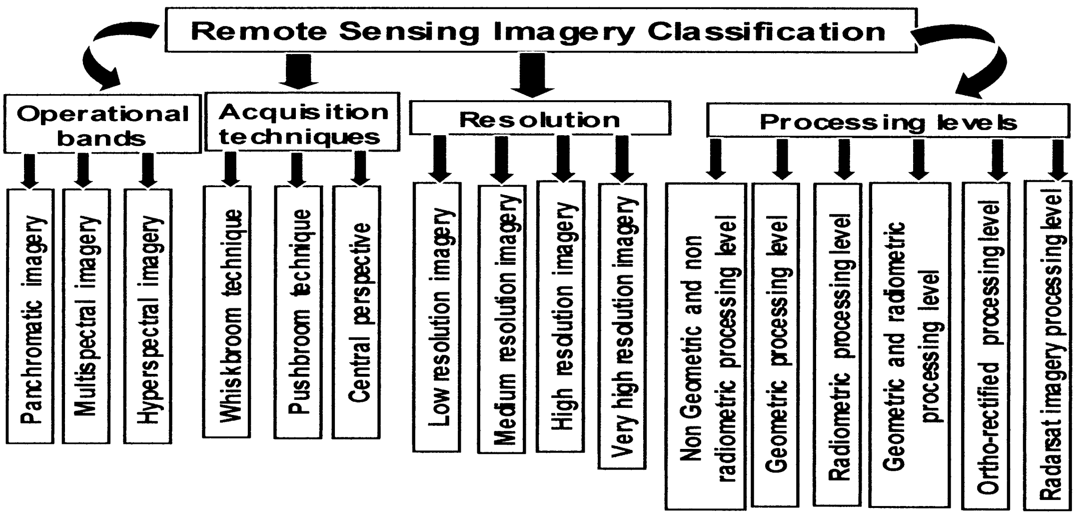

Fig.1. Remote sensing imagery classification criteria [7].

Table 1
Classification of space imagery for the six satellite systems [7]

Factors	Operational Band			Acquisition technique			Resolution				Processing level					
Satellite	PAN	MS	HS	Whiskbroom	Pushbroom	Central perspective	Low (30-300)	Medium (5-30)	High (1-5)	V.High <1	A	B	C	D	E	F
LANDSAT	√	√	-	-	√	√	√	√	-	-	√	-	√	√	-	-
SPOT	√	√	-	√	√	-	-	√	√	-	-	√	√	√	√	-
IRS	√	-	-		-	-	√	√	-	-	-	-	-	√	-	-
SPIN 2	√	-	-	-	√	-	-	√	√	-	√	-	-	-	√	-
IKONOS	√	√	-	√	√	-	-	-	√	√	-	√	-	-	√	-
RADARSAT	-	√	√	-	√	-	√	√	-	-	-	-	-	-	-	√

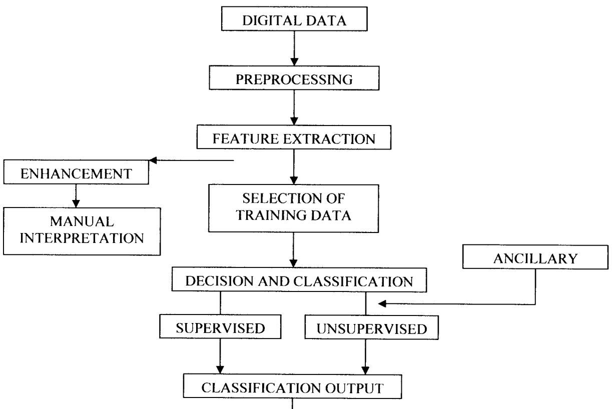

Fig. 2. Flow chart of idealized sequence for digital image analysis.

Table 2
Orbital characteristics of the six satellite systems [7]

Sate llite	LANDSAT			SPOT			IRS				SPIN2	IKONOS	RADAR -SAT
Parameter	1-3	4-5	7	1-3	4	5	1A	1B	1C	1D			
Sensor Mode	1-3	RBV, TM	ETM+	HRV	HRVIR, VMI	HRG HRS VMI	LISS-I	LISS-II	Pan LISS-III WiFS	Pan LISS-III wiFs	TK-350, KVR-1000	Pan, MS	SAR
Altitude (km)	907-915	705	705	818-833			904	904	817	821	190-270	680	798
Inclination (DEG)	99.2	98.2	98.2	98.72			99.049	99.049	99.049	99.049	65	98.10	98.6
Period of revolution (min)	103	99	99	101			103.193	103.193	101.35	101.35	-	98.3	100.70
Repeat coverage (days)	18	16	16	26			22	22	24	24	8-15	14(Max)	24

8. Potential use of space imagery for mapping

Space imagery is widely used in mapping projects for topographic and thematic mapping. Space imagery data for mapping purposes could be used in three ways. The first one is to produce topographic maps. The second one is to produce satellite image maps. The last one is the production of thematic maps, either by using satellite image maps as base maps or by deriving thematic information from the image data [6].

8.1. Information content

In mapping from space imagery, the information content of the images is more important than geometric accuracy. An indication of the information content is the pixel size on the ground.

The capability of detection and identification of features in the space imagery varies from satellite to another. Of course, the detection and identification of features depend on the type of the feature, its size and shape, the contrast between the feature and its surrounding and its relationship with other known features.

Each of the six satellites under investigation has its own capability to detect objects and extract features. This privacy refers to the technical characteristics of each satellite. IKONOS imagery offers high information content with reliable completeness comparing to the other satellites.

8.2. Achieved accuracy

Many available researches of some space imagery from the six satellites are studied to know the potential use of these images for topographic and thematic mapping. The achieved accuracy for the produced maps from these images is presented in table 3.

9. Proposed guide to software selection

With the wide spread of space imagery in the commercial world markets and using them in many applications, especially in mapping field, the user-need to select the most appropriate space imagery for a specific

Table 3
Suitable map scale vs. achieved accuracy [7]

Satellite	Horizontal accuracy (m)	Vertical accuracy (m)	Map scale
LANDSAT	>50	-	1:25,000
SPOT	6	(7-10)	1:25,000
IRS	6	10	1:50,000
SPIN 2	TK-350 (7-10)	(4-5)	1:25,000
	KVR-1000 (2-3)	-	1:10,000
IKONOS	2	3	1:2,500
			1:5,000
RADARSAT	(10-100)	(10-50)	1:50,000

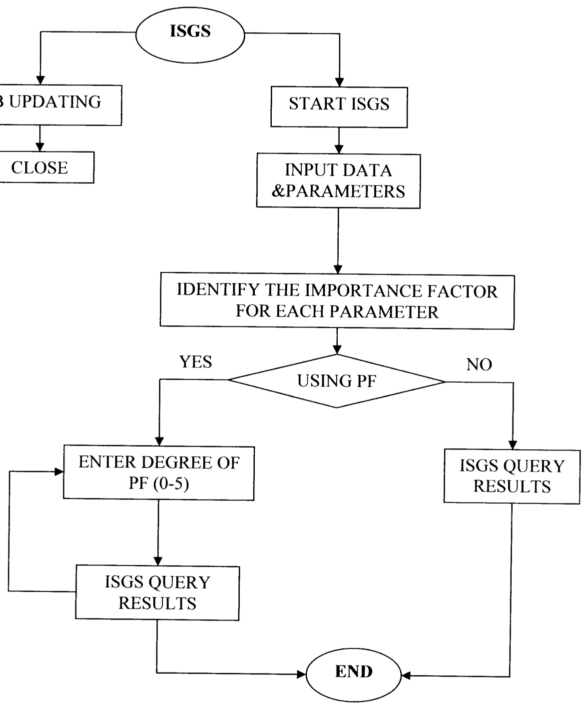

Fig. 3. Flow chart of the proposed guide software.

application (project) is appeared. Furthermore, not all images are suitable for producing maps at all scales under several circumstances and the important question comes up in mind is which image for which map?

The proposed guide software is essential to help the space imagery users in selecting the right image for the desired project. This software could be called Image Selection Guide Software (ISGS) [7]. This software contains three main features namely:

1. Effective project parameters.
2. Mathematical models.
3. Space images databases.

9.1. Effective project parameters

The parameters effect in selecting the suitable image, which should be considered when thinking of the problem in hand, are the application in hand, the desired map scale, both the horizontal and the vertical accuracy needed, the area where the project is conducted, the available budget of the whole project, the max image delivery time allowed for the completion of the project and finally the image rectification level wanted.

All these parameters should be studied and arranged according to the user needs. An importance factor should be assigned to each one of them. The software should take into account the influence of these importance factors through the processing and choosing the query results through the usage of Priority Factors (PF).

9.2. Mathematical models

Some of the important mathematical models must be involved in this software. These mathematical relations join all the parameters together, relate them with the available images databases and help choosing the correct images which satisfy the user needs.

9.3. Space images database

The space images databases could be technical and/or commercial data which are available in the related internet web sites for the six satellite systems in concern. The proposed software should have the options of adding new systems if the databases become available in addition to the option of updating the existing databases with any new changes occurred. The flow chart of this proposed guide software is shown in fig. 3.

10. Conclusions

Using the advanced technique in mapping applications from remote sensing imagery is completely noticeable and apparent. Furthermore, space imagery has a high potential of producing maps of different scales with a good quality (accuracy, reliability and information content). Some important features are highlighted with some limitations. A guide software assist the user in selecting the most appropriate space imagery for his/her application (project) is proposed. The proposed guide software is considered as a new addition to the remote sensing field. Its creation is highly recommended.

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