Image selection guide software for optimum use of remote sensing imagery for mapping applications

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Mapping from Remote Sensing Imagery is a very well known process and a significantly matured field. For any project, the imagery is being ordered, control points are surveyed, rectification procedure is performed, and maps are updated. The first and most important step is the “image selection”. Remote sensing imagery has different characteristics that identify the possibility of using an image in a certain application. For instance, mapping at scale of 1:2500 requires very high-resolution imagery with certain accuracy and characteristics that differ from the requirements for mapping at a scale of 1:50000. The optimum selection of the desired image based is upon the project needs and is a must for cost/time/effort-effective projects. This paper presents a new tool, Image Selection Guide Software (ISGS), that helps the user in selecting or narrowing down the selection range for the right image, based upon the project actual needs. The user inputs the project parameters, the program then uses pre-defined mathematical models to convert the project parameters into image characteristics, search the pre-designed image database, and finally provides the user with the selection that would satisfy his/her needs.

يعتبر إنتاج الخرائط باستخدام صور الأقمار الصناعية من المجالات المتقدمة. هناك العديد من الأبحاث أجريت لتحديد أدق وحسن الطرق لانتاج الخرائط بهذه الطريقة. تختلف هذه الطرق باختلاف نوعية المشاريع و كذلك باختلاف التطبيقات التي تستخدم فيها هذه الخرائط. برغم تعدد و اختلاف طرق إنتاج الخرائط باستخدام صور الأقمار الصناعية، إلا إنها تتحد في الخطوة الأولى والأساسية في أي من هذه المشاريع ألا و هي (اختيار الصورة المناسبة لاحتياجات المشروع). في العادة يتم اختيار الصور من الخبرة العملية بالإضافة إلى الميزانية المخصصة للمشروع. بجانب هذين العاملين لا بد من وجود برنامج محدد مبنى على خطوات علمية لمساعدة المستخدم العادي في اختيار الصورة المناسبة. هذا البحث يختص بإنتاج برنامج يساعد المستخدم العادي وأيضا" ذو الخبرة على الاختيار الأمثل للصورة بناء على متطلبات المشروع. يقوم المستخدم بتحديد العوامل المحددة للمشروع ويقوم بإدخالها للبرنامج و يقوم البرنامج بتحديد أحسن الاختيارات للصور المناسبة لهذا المشروع بناء على علاقات رياضية محددة تحول عناصر المشروع إلى خصائص الصور المناسبة.

Keywords: Remote sensing, Imagery, Mapping, Visual basic, Resolution

1. Introduction

Nowadays, space imagery is being widely used in mapping projects and applications. In any of those projects, the user selects the suitable image for his/her project, performs different rectification process, and then uses the image to extract the information required for the concerned project. The first and the most important step is the “image selection”.

Remote sensing imagery has different characteristics. Those characteristics identify the possibility of using an image in a certain application. For instance, mapping at large scale requires very high-resolution imagery with certain accuracy and characteristics that differ from the requirements for mapping at a smaller scale. The optimum selection of the desired image based upon the project needs is a must. The selection of the so-called right image usually depends upon budget and user experience. Although this experience is very important, the image selection process should consider different aspects of the project. Therefore, the need for a new tool that guides any user to the right decision is very important. First the user should identify and enter the project parameters, the program/tool then creates multiple thresholds based upon pre-defined mathematical models, and finally a database search in being conducted to identify the suitable image (s).

This paper demonstrates the development procedure for a new tool, Image Selection Guide Software (ISGS), that helps the user in selecting or narrowing down the selection range for the right image based upon the project actual needs.

In the next section, the development procedure of the ISGS will be demonstrated

2. Development of software

The main idea of developing ISGS is to help users, even inexperienced ones, in selecting the *right* image for the *right* project. The user should enter the project's parameters and then the program will identify the reasonably suitable imagery for such a project. Consequently, the first step in developing ISGS is to identify the parameters that should be considered.

Different parameters that may be of interest for any mapping project have been identified and taken into account in developing ISGS [1], namely:

- Map scale range for the project.
- Horizontal accuracy for the project.
- Vertical accuracy for the project.
- Required image rectification level.
- Area of the project.
- Available budget for buying imagery within the project.
- Acceptable image delivery time.
- Project Application.

As we can see, each of the previously mentioned parameters has direct and indirect relation with remote sensing imagery characteristics. Since the main aim of the ISGS is to select the suitable imagery for any concerned project, all of the previously mentioned parameters have to be converted to present image characteristics. The following subsections present such a conversion and the mathematical rules used to develop ISGS.

2.1. Map scale range

The required map scale for the project can be directly related to image resolution. As stated by [2], the relation between the ground resolution and the map scale can be expressed as follows:

Map Scale=4000 * Ground Resolution (meter/line pair). (1)

Ground Resolution (meter/line pair) = N * pixel size (meter). (2)

Where, 4000 is a constant value identified based upon previous work experience as reported by [2], *N* is a constant value ranging from 1.5 to 2.82 [3] . This means that N pixels are required to present the same information content as one line pair. [4] reported that the ground resolution equals 1.0 up to 1.5 times the pixel size. For *ISGS*, the value of *N* was taken as (1.0) [1]. In other words, the relation between the map scale and image pixel size can be expressed as follows:

Pixel Size (m) = Map Scale / 4000. (3)

2.2. Map scale and horizontal accuracy

Horizontal accuracy can be generally presented using the Standard Deviation (σh). The main issue here is to relate the standard deviation to suitable map scale and consequently to pixel size using Equation 3. According to the United States National Map Accuracy Standard (NMAS) and as considered within ISGS, the relation between map scale and standard deviation is expressed by:

Map Scale = σh (mm) / 0.3. (4)

Knowing the required horizontal accuracy, the corresponding map scale that satisfies the required accuracy can be computed and consequently the suitable range of imagery pixel size.

2.3. Contour interval & vertical accuracy

Contour interval and the vertical accuracy required for any project affects the range of scale that can be manipulated within such a project. Considering the United States National Mapping Accuracy Standards (NMAS), the following table shows the relationship between map scale and expected corresponding contour interval as considered within ISGS [1].

Table 1
US. national mapping elevation accuracy standards [1]

Map scale	Standard elevation accuracy	Contour interval
1: 5 000	$\pm$ 0.3 to $\pm$ 0.6m	1 to 2m
1: 10 000	$\pm$ 1.5m	5m
1: 25 000	$\pm$ 3m	10m
1: 50 000	$\pm$ 6m	20m

In other words, given the required contour interval or vertical accuracy, the map scale range can be identified.

2.4. Project area and imagery budget

It is important to consider the imagery budget available for a certain project. The user should enter the project approximate area and the available budget. The program then calculates the number of images required to cover the area. The total image price is then compared with the available budget. This process can be represented as follows:

$$\text{Image Price}(\$) = \text{Image Project Budget}(\$) / \text{Project Area}(sq.km) \,. \quad (5)$$

2.5. Project application

Project application can affect the selection criteria of ISGS. Based upon the application required, different imagery band ranges may be used and consequently different imagery types. The following table represents different applications and their corresponding band ranges.

2.6. Image delivery time

According to the project applications, acceptable image delivery time may differ. Emergency applications require fast delivery than regular mapping applications. Within ISGS, the user has to enter the maximum acceptable delivery time as a main factor for the selection criteria.

2.7. Image rectification level

Due to the fact that the user may or may not have the tools and software required to rectify remotely sensed imagery to obtain the approximately correct orthomap, he/she may need the image to be partially or fully ortho-rectified. This factor was considered in designing ISGS and the user should enter the rectification level required. In ISGS, rectification levels have been divided into three main levels, namely, Unrectified, Rectified, and Orthorectified.

By entering the previously mentioned parameters and converting them to image-related characteristics, the program will be connected to imagery database. Imagery database is a predesigned database containing imagery information.

In order to set up the underlying database, a research has been conducted first to acquire information about suitable imagery. A decision has been made to include six types of remotely sensed data based upon their frequent use in mapping applications, wide band range, and different sources, namely, LANDSAT – SPOT - IRS-1C/1D - SPIN-2 – IKONOS -RADARSAT.

For each type of those imagery, information about pixel size, delivery time, processing level price, bands, coverage area were used to construct the database.

3. Software work flow

Image selection guide software (ISGS) consists of eleven forms and one module. The system starts with the opening form, shown in fig. 1. This form contains two-command

Table 2
Application vs band range [5]

Spectral region	Band range (μm)	Application
Blue, green	0.47-0.57	water Penetration
Red	0.57-0.69	vegetation & cultural feature discrimination
Near infrared	0.76-1.05	land & water interface & vegetation discrimination
Short wave infrared	1.55-1.75	soil moisture
Pan.	0.51-0.73	topographic mapping

buttons, one of which allows the user to access the DataBase (DB) to delete, add, or update the DB in any manner. By pressing the "DB UPDATE" button the "DB UPDATE" form appears. As shown in fig. 2, this new "DB UPDATE" form contains 6 command buttons each of which allows the user to access the corresponding DB and to update it in any manner, as shown in fig 3.

On the other hand, if the user presses the "START ISGS" button within the first form the program then starts with the "ISGS [Data Entry]" form, as shown in fig. 4. Using this form the user has to enter all required parameters and then presses the "PROCESS" button. Another form would appear, "Priority Filters" form, as shown in fig. 5. This form allows the user to enter the importance factor for each parameter. In other words, the user can use this form to arrange the project parameters in terms of significance to the concerned project. The importance factor scale has been designed to range between 1 and 6. the value of "1" should be given to the most important parameter and "6" for the lowest one. This process allows the system to identify and arrange the existing factors. This arrangement is useful when the entered project parameter are really tied and restricted and consequently no or insufficient answer is given. The system then can neglect some parameters based upon the user request for better selection. If the user selects to process his/her request without any priority filters, the system then takes all the parameters into consideration. On the other hand, if the user requested to proceed with priority filters, he/she has to enter the number of parameters to be ignored, as shown in fig. 6.

If the user selects the number "2", then the lowest two important factors will be ignored when searching the DB, in our case "Time" and "Rectification Level".

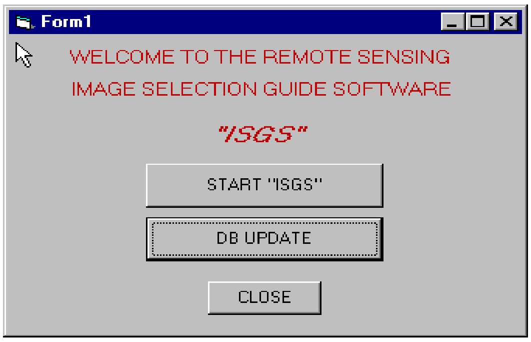

Fig. 1. Starting form.

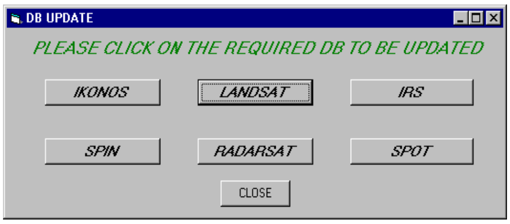

Fig. 2. DB updating form.

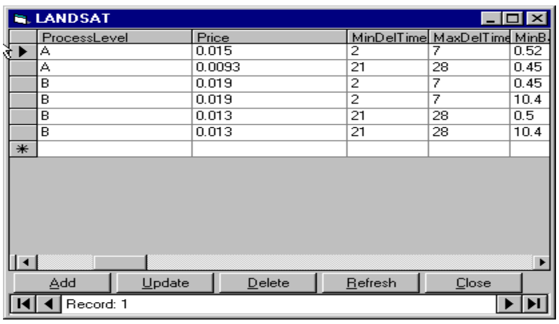

Fig. 3. DB updating form (LANDSAT table).

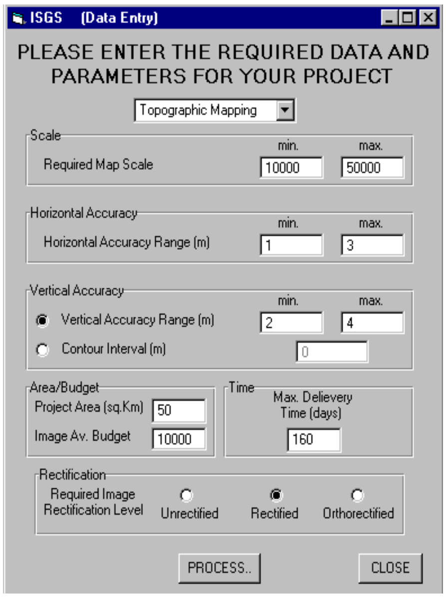

Fig. 4. ISGS data entry form.

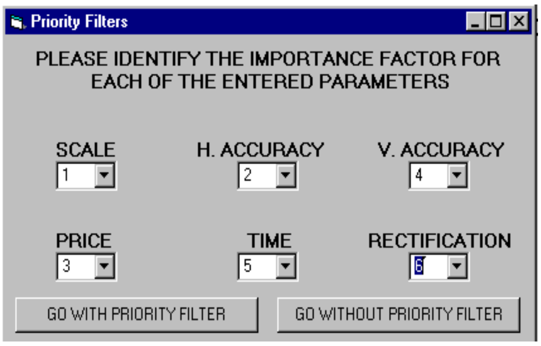

Fig. 5. Priority filters form.

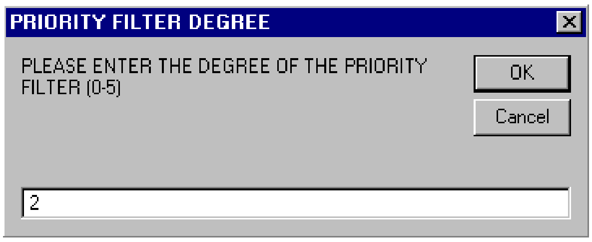

Fig. 6. Priority filters degree form.

The last step in the process is to query the DB and to present the results to the user. The system takes all the entered parameters and all the factors required to be concerned and produces the range of image characteristics to search the DB, based upon the mathematical models presented earlier. As shown in figs. 7-a and 7-b, the "ISGS QUERY RESULTS" form appears containing all possible selections and the user then has to decide which one to use. It is important to mention here that all image types within the presented results would satisfy the project needs. Fig. 8 presents a flow chart showing the program flow and the main processing steps.

4. Program testing

The last step of developing the ISGS is the testing stage. In order to test the system, a comprehensive research was conducted to compare the program results with previous actual projects. Project parameters are identified, and then the resulted imagery selection from ISGS is compared to the actual used imagery within the concerned project. A summary of the test cases are shown below:

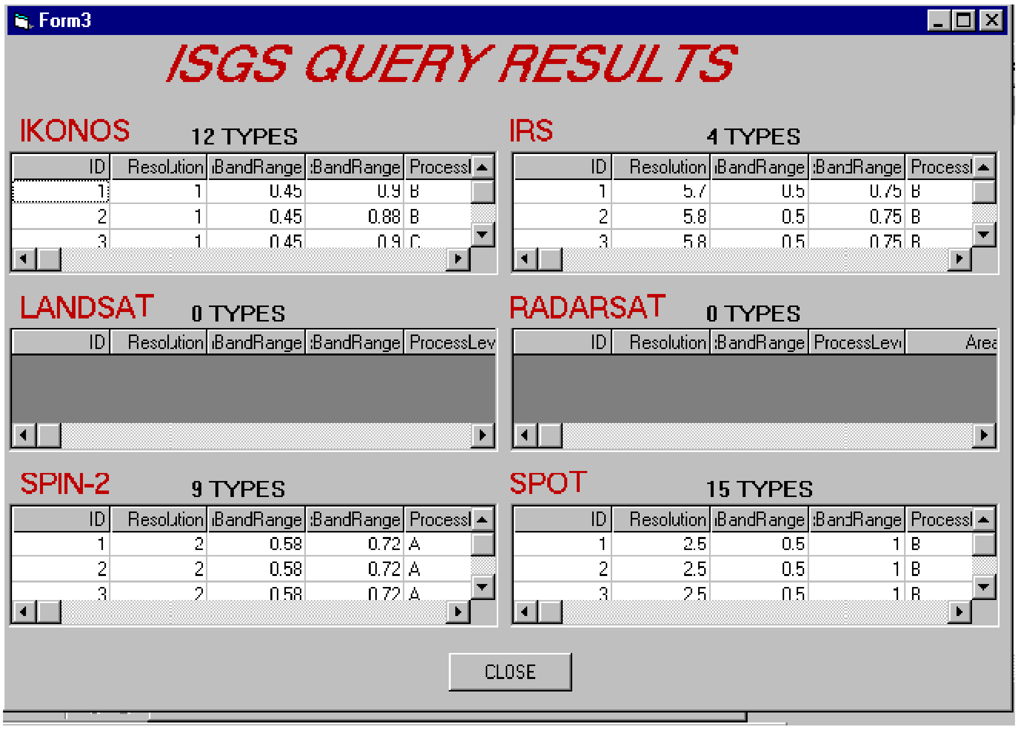

Fig. 7-a. Query results form (using priority filters).

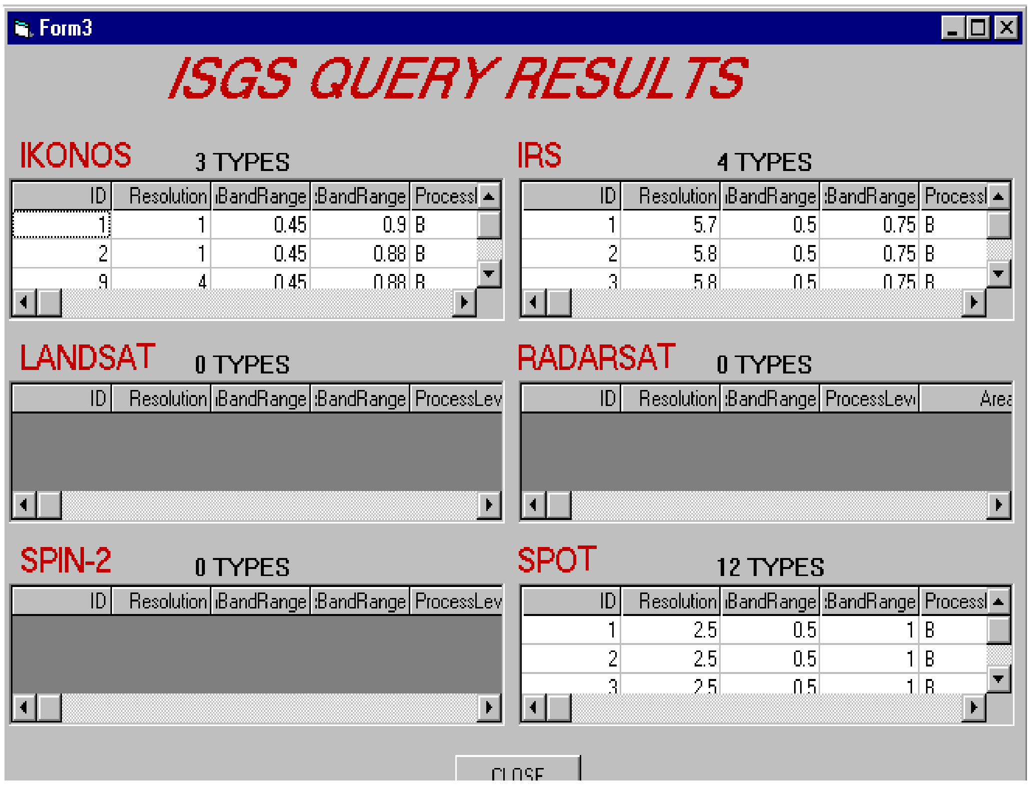

Fig. 7-b. Query results form (without priority filters).

Case 1:
Place: Sorsogon Province – Luzon- Philippines [6]
Used Parameters:
Area: 1400 sq km
Scale: 1:5000-1:10000
H accuracy: 1.2-1.5 m
V accuracy: assumed 2-4 m
Rectification: rectified
Actual Used Imagery: IKONOS GEO
Suggested image BY “ISGS”: SPOT & IKONOS

Case 2:
Place: Alexandria- Egypt [7]
Used Parameters:
Area: 2.0 sq km
Scale :1:25000
H accuracy: 2.4 – 5.3 m
V accuracy: assumed 4-7 m
Rectification: rectified
Actual Used Imagery: SPOT
Suggested Image By “ISGS”: SPOT & IRS

Case 3:
Place: Giza- Egypt [7]
Used Parameters:
Area: 2.8 sq km
Scale :1:10000 and smaller
H accuracy: 1.4-3.7 m
V accuracy: assumed 4-7 m
Rectification: rectified
Actual Used Imagery: SPIN2 (2m resolution)
Suggested image by “ISGS”: SPIN2 & SPOT

Case 4:
Place: Rio Claro – State of Sao Paulo- Brazil [8]
Used Parameters:
Area: 702 sq km
Scale: 1:50000
H accuracy: 22.48 – 26.78 m
V accuracy: assumed 10 m
Rectification: rectified
Actual Used Imagery: SPOT
Suggested image by “ISGS”: SPOT & IRS

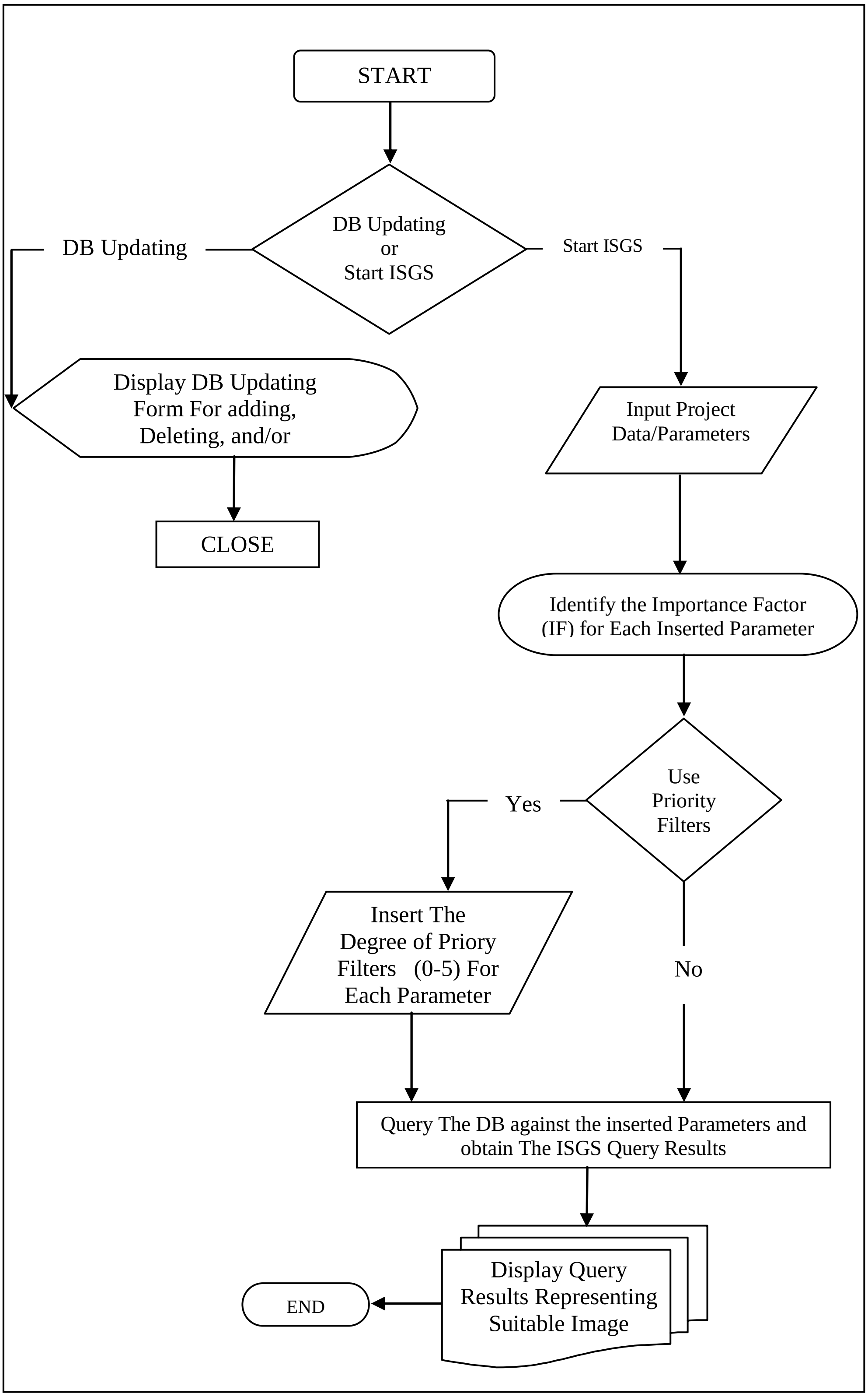

Fig. 8. ISGS work flow (main steps).

Case 5:
Place: Madison County (Ohio)- USA [9]
Used Parameters:
Area: 4 sq km
Scale :1:24000 – 1:10000
H accuracy: 2 – 3.5 m
V accuracy: assumed 3-4 m
Rectification: rectified
Actual Used Imagery: IKONOS GEO
Suggested image by “ISGS”: IKONOS & IRS & SPOT

Case 6:
Place: Campania- Italy [10]
Used Parameters:
Area: Approximately 169 sq km
Scale :1:25000 and smaller
H accuracy: 6-10 m
V accuracy: assumed 7-10 m
Rectification: rectified
Max. Delivery Time: 7 Days
Actual Used Imagery: SPOT Panchromatic 1B
Suggested image by “ISGS”: IRS & SPOT

Case 7:
Place: East Ottawa- Canada [11]
Used Parameters:
Area: 1092 sq km
Scale :1:50000 and smaller
H accuracy: 5-10 m
V accuracy: around 10 m
Rectification: rectified
Actual Used Imagery: Panchromatic IRS-1C
Suggested image by “ISGS”: IRS & SPOT

From the previously demonstrated testing cases, we can recognize that in all cases the ISGS results always match the selected imagery by experienced users that produced the desired accuracy. In other words, if inexperienced user will use the software and just enter the correct project’s parameters, the software will guide him/her towards a correct decision.

5. Conclusions and future research

As shown in the previously conducted research, not every image can be used in mapping applications for different situations and/or mapping projects. Suitable images are ones that serve the needs of the desired project with optimal cost and required accuracy. The developed software helps in selecting suitable remote sensing imagery for mapping applications based upon existing project parameters. The following may be concluded:

1. The software will help in optimal remote sensing imagery selection and will provide the most suitable types of imagery for the desired project if the parameters are entered correctly and no matter how proficient the user should be.
2. The software provides all possible choices, based on the source DB, for imagery that may be used economically and reliably to serve a different number of applications.
3. Using Visual Basic allows flexibility in modifying the software when appropriate to accommodate user needs such as pre-defined selection rules and/or parameter checking procedure, i.e. ISGS is extendable.

In addition to that, further future research should be conducted to modify the developed software in different aspects, namely:

1. Parameters, such as wider band range and lower resolution imagery, should be accommodated and tested by the software to economically serve a wider range of applications, namely, thematic mapping, environmental management and crops change detection applications.
2. A rule-based procedure should be applied. Predefined rules should be developed and inserted in a rule-based mode application to detect and help the users in ignoring and/or rejecting parameters to reach better selection.
3. Although the imagery database covers the most recent types of imagery, it should be expanded and regularly updated.
4. New techniques, such as artificial intelligence, may be used in an interactive mode to guide the users, specially inexperienced, in manipulating the major factors, accuracy, time, and cost, for better and more economic selection.

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