# INTELLIGENT ENVIRONMENT FOR INTERPRETATION TASKS OF REMOTELY SENSED IMAGES.

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**ABSTRACT:**

Digital image interpretation tasks in Remote Sensing applications have been exhaustively studied. Achievements in the area have used deterministic and statistical algorithms. Usually these algorithms only base their decisions on spatial data furnished as representative of patterns (classes). This paper presents a study on the use of Artificial Intelligence (AI) Techniques for interpretation purposes. The following topics are covered in the paper: representation of the knowledge involved in interpretation tasks (local and spatial ones), development of an intelligent interface (for Brazilian users) for interactive classification tasks and educational purposes in Remote Sensing, and the use of the PROLOG language as the principal tool for implementing the inference rules. As a preliminary result a prototype has been tested translating Natural Language queries (in Portuguese) into a Geometric representation language.

**KEY WORDS** Artificial Intelligence, Classification, Education, Image Interpretation, Remote Sensing Application

## 1. INTRODUCTION

### 1.1 Man-Machine Interaction

Man-machine interaction (**MMI**) has not been efficiently achieved with computational systems that focus on computational objectives without regarding the user's "intention" under his query. So, the task is (or not) always performed and no dialog choice is given to the user in case he is not an expert on the interaction language required by the system. This has happened because software development approaches have been directed to procedures or data what make the systems parametric and require a detailed knowledge of involved parameters.

Many researchers have worked on the development of tools to turn computational systems into user friendly environments. The approaches used include user's characteristics and necessities modelling. One can find several examples of systems that try to improve the MMI in the literature. That is the case of Thompson (1984) who developed a menu system to interface a data base in value determination. In his system the user builds up his query through a decision tree as he follows up the specified menus. In case of doubts the user is required to add up knowledge to the tree. Therefore, the knowledge used to solve the problem is gradually attached to the system turning it into a friendly and easy to manipulate system. Ambler and Burnett (1989) use icons in the development of interactive graphic languages with which the user does not need to write procedures to perform his tasks. The tasks are pre-programmed and can be activated through mouses or any other device after they have been selected.

The aim of these systems is to make the user efficiently perform his tasks bringing up ergonometric advantages. But the tasks are not automatically performed under the user's viewpoint, once he participates through out the whole process specifying procedures and parameters. That is, during the task execution the user is required to interact with the machine providing arguments and choosing procedures to be adopted. Besides that, some of the tasks may require the composition of several parametric procedures and/or sophisticated objects which can make its execution difficult even using icons or menus.

This work proposes the use of Natural Language (**NL**) in a cognitive knowledge-based approach to develop an intelligent environment to efficiently improve MMI. The knowledge-based environment translates the user's query into the adequate set of actions to perform the specified task. The user makes his intention explicit interacting with the environment through menu systems, icons or questions, letting his intention be detected and mapped to the set of actions to be adopted. The environment uses the Brazilian Portuguese Language (BPL), in which the users' queries are made in free NL within a restricted application domain.

The knowledge resulting from the interactions in the interpretation and analysis processes is stored in the environment, establishing a knowledge acquisition process (Oliveira, 1988).

Some researchers have used NL and other Artificial Intelligence techniques in the development of tools for MMI improvements. Schmitt (1989) developed a system to generate chained morphological transformations sequences building up morphological programs. The domain expert user may write his own morphological programs. Without this system he would need to know the domain parametric language, in order to perform his tasks. This system was developed in the restricted Mathematics Morphology domain for the English Language interaction. Oliveira (1990) developed the IDEAL system which is a tool for constructing NL interfaces for expert systems. While interacting with the user the IDEAL system provides the sufficient linguistic universe for comprehending, interpreting and translating NL phrases to a knowledge representation. The environment is capable of mapping a domain knowledge to a transformation language, such as, a Geometric Transformation Language (as used in CAD systems, Computer Graphics, etc), a Digital Image Processing Language as in Batchelor (1986), a Digital Signal Processing Language for digital filters sinthesis and/or design as in Nie et ali (1991), etc.

### 1.2 Generalities

The solution to a domain problem always involve a great quantity of knowledge which sometimes is not well organized to provide the best solution. That happens in all of the application domains and so it is not different in the Digital Image Processing Domain, specially when dealing with radar or multiespectral satellite images that have much information, but yet are not well interpreted. One of the problems arises from the fact that when using Digital Image Processing Software, the domain experts dedicate much of the time to learn how to operate the systems to choose procedures and provide parameters.

Corr et ali (1989) present a system for automatic knowledge-based segmentation of remotely sensed images. Time sequences of remotely-sensed data information are used together with cartographic map data and domain expertise in modelling the scene in terms of segments and their possible classes. Srinivasan and Richards (1990) use knowledge-based procedures to provide a new scheme for incorporating several knowledge sources in the classification process. Silva and Bittencourt (1991) considers the use of several knowledge representation techniques to represent the knowledge involved in interpretation of meteorological radar images. The knowledge sources are represented using frames, semantic networks, and/or production rules representation schemes within a blackboard architecture that permits different knowledge sources share the same data, simultaneously or sequentially. In this system the weather is monitored by the radar and the images are numerically processed before the representation. In critical cases the system activates an alarm calling for experts interference.

There exist many knowledge-based systems that try to solve specific Digital Image Processing problems specially those related to automatic Image Interpretation. In all of them, however, the MMI is not efficiently achieved, once the user (domain expert) is required to participate through out the whole process. And then, the tasks are not automatically performed from the user's point of view. The decisions are always taken by the user that must be an expert in the application domain and the systems used.The aim of this work is to provide an environment through which the systems may be well used to solve problems in a specific domain. Using NL to communicate with the system the user may specify his intention, avoiding unnecessary computation, and the tasks are only performed after the correct procedures and parameters specifications. Therefore, the tasks are automatically performed from the user's point of view.

The proposed environment translates the user's query to a tranformation language, that is, the environment maps the query to the procedures specification to be adopted for task execution. The parameters are still provide by the user. But the environment friendly requests them, sometimes explaining the use of the parameters and giving examples. This characterizes a user training process through the system that can detect any specification fault before the execution process. That happens because the domain knowledge is also represented and so environments like this may be used in education tasks in remote sensing.

The greatest advantage of using NL in intelligent environment is that instead of dedicating time to learn how to specify procedures and parameters to efficiently use software systems, the user can dedicate his time searching for new problem solution estrategies and methods, thus enhancing the solution space.

## 2. SYSTEM DEVELOPMENT

### 2.1 Environment Architecture

This work does not focus on the knowledge representation of remotely sensed images. This has been studied by several researchers as mentioned in section 1.2 and can be adapted in the case of the digital image processing domain or any other domain. The objective of the work is to improve MMI in software usage. That is, turn parametric and difficult to use systems into friendly environment. With this kind of system the user may specify his queries using his own language within the restricted domain.

The environment developed is composed of modules for linguistic interpretation, translation to the set of actions, task execution, and graphic representation. The linguistic and domain knowledges are represented using Minsk's frame representation conception as in Winston (1975), that permits stereotype representation such as the description of an object (e.g., a chair) or a situation (e.g., going into a classroom). These knowledge sources are used within a blackboard approach, so that, knowledge sources responsible for inference rules may share the same data, searching for the solution to the specified problem, see figure 1.

### 2.2 Environment-Description

The application domain considered is restricted to 2D computer graphics where it is possible to perform some tasks on regular geometric objects such as rectangles, triangles, squares, circles and lines. Examples of tasks are translation, scaling, color alteration and rotation. To implement the frame representation of this domain a frame language was used based on the one proposed by Arariboia (1988).

The prototype was developed in the C language for graphic presentation and PROLOG for knowledge representation and inference rules implementation. Both languages share a knowledge source where the graphic status is represented.

As the application domain changes the inference rules and the knowledge necessary may also change. Then the user must specify the files where his knowledge descriptions are. The Natural Language processing module is an adaptation of the IDEAL system of Oliveira (1990) mentioned in section 1.1. It performs the queries' pragmatic-semantic-lexical knowledge acquisition, which is one of the most difficult tasks.

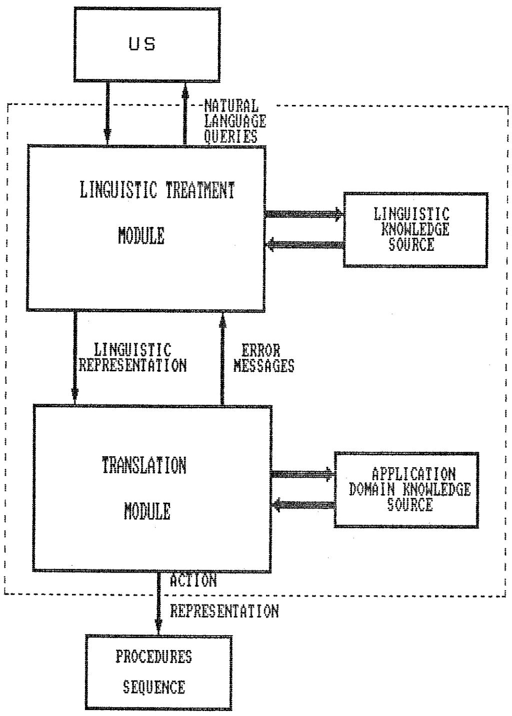


Figure 1 - Environment Architecture

The domain knowledge is represented using the frame model. The description of the objects builds up a hierarchy starting off as generic objects, then instances of objects and establishing links among them such as "a kind of" or "part of", see figure 2.

After discovering the user's intention the linguistic module sends the semantics of the query to the translation module which builds up the program to execute the task. This program is constructed through the use of primitives which are previously defined by the user. In the prototype developed only 4 primitives are considered to some situations in the domain. Other situations may need the definition of new primitives. The defined primitives are as follows:

**ident** - identifies the object in the domain, that is, checks if the object requested is part of the domain.

**loc** - searches for the object description in the knowledge represented and returns all of its attributes, such as, location, color, width, size, orientation, etc. This primitive only works if **ident** has previously been activated.

**alt** - performs all of the changes requested, such as, color, width, size, orientation alteration. Its activation is preceeded by primitive **loc** activation.

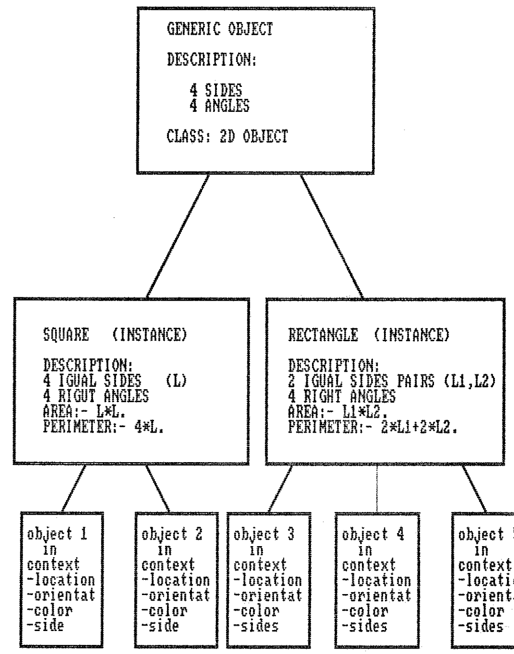


Figure 2 - Frame representation of some objects in the domain.

**gen** - creates or generates new objects in the context. The user defines all the object's attributes.

An example of the use of these primitives can be found in example 1.

**Example 1:**

**User's query:**

**"Mudar o quadrado da posição x,y para w,z."**
**(Change the square from location x,y to w,z).**

**The transformation would result in:**

**(ação:[ident,loc,alt]) (action:[ident,loc,alt])**

**(atributo: [posição_atual:(x,y), posição_destino(w,z)])**
**(attribute:[original_location:(x,y), destiny_location: (w,z)])**

**(objeto : [quadrado])(object: [square])**

The example shows that the user specifies the task he wants to execute and simultaneously provides the necessary parameters ( x,y,w,z). In this process he does not need to know much of the graphic system he is using.

In fact the primitives are acting on the represented knowledge using the frame language referred to previously. This makes the user's procedures and parameters specification a high level abstraction task.

As mentioned before the knowledge representation and the inference rules are specified using the PROLOG language. The PROLOG language is a declarative language that permits easy rules coding for users. Besides it has an inference motor adequate for the proposed environment.

The environment can be adapted to any other domain as mentioned previously. Other inference rules may be needed and then the user must code other primitives to perform the tasks. In the Digital Image Processing domain the environment may be able to translate queries as in example 2 (interactions in Portuguese).

**Exemplo 2:**

**USUÁRIO : Suavizar a imagem.**
**(USER : Smooth image)**

**AMBIENTE : Especifique a imagem a ser filtrada.**
**( ENVIRONMENT : Specify the image to be filtered)**

**USUÁRIO : (Fornece o nome da imagem)**
**( USER: (Provides the name )**

**AMBIENTE : O filtro passa-baixa deve preservar a borda?**
**(ENVIRONMENT : Is it an edge preserving smoothing filter?)**

**USUÁRIO : (O usuário pode responder de acordo com a pergunta do sistema ou pode indagar o que significa preservar a borda, ao que o sistema pode atender explicando o efeito de preservarção da borda e exemplificando)**
**(USER : May answer accordingly or ask about edge preserving which the environment may explain and give examples).**

All the information provided in example 2 may be stored so that in the next user's interaction requesting the same processing the environment can promptly perform its tasks recalling the definitions stored.

### 2.3 Results Obtained

The environment discussed here is implemented for the 2D Computer Graphics domain. Instead of trying to solve all of the problems concerned to 2D transformations the work aims to show the usefulness of designing Natural Language environments for Man-Machine Interaction in system development in any application domain. The task involves people dealing with Artificial Intelligence such as Knowledge Engineers, and domain experts such as those working in Computer Graphics, Remote Sensing, Image Interpretation, Digital Signal Processing, etc.

The way the prototype is designed permits some interactions with the user. So that environment successfully performs tasks as stated in example 1. While building up his request the user maintains a high level dialog with the machine. That is, he specifies everything in his own language and does not get involved with detailed parameters specification. Thus establishing an improved Man-Machine Interaction.

Providing the linguistic universe for Natural Language interaction the environment can show its efficiency with people without much experience in computer use and/or the application domain considered. The storage of knowledge involved in problem solution permits that most of the situations be treated automatically from the user's viewpoint thus avoiding redefinition of the user's intention.

## 3. CONCLUSIONS

The prototype developed showed the possibility of using Natural Language in knowledge-based systems which improves Man-Machine Interaction. Thus users can face computational systems as real helping tools once they do not need to get involved with detailed specifications that make them learn several lessons on systems use before efficiently use them to solve their problems. Then time used before for training purposes can now be dedicated to new solution strategies and methods discoveries. Besides, the tasks can be executed automatically under user's viewpoint, so that, the efforts for problem solution can be measured and evaluated.

Natural Language has not been used in system design because of the problems involved. It is a very dynamic subject where the rules are constantly changing according to customs, culture, etc., within a region. This means new rules and data storage. Also, the same feeling can be expressed in several different ways which requires a complete linguistic knowledge representation that may require great memory capacity from the hardware used. Restricting the domain it is possible to use free NL to treat a reduced number of situations.

The initial work objective was to design a system where the Remote Sensing experts would perform several Digital Image Processing activities, specially those related to Image Interpretation involving different knowledge sources. The greatest problem found concerned image knowledge representation. And then, an environment for 2D Computer Graphics domain was developed. The objects treated in this domain are simple to be represented. However, image knowledge representation has been studied by some authors already and the prototype described can now be tested in Image Processing. The same system philosophy design has been used to develop an interface for an image processing software that performs morphological processing on images.

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