KNOWLEDGE BASED APPROACH FOR ENHANCEMENT OF REMOTELY SENSED DATA

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ABSTRACT:

The most fundamental operation in an image processing problem is image enhancement. Although there are numerous algorithms for image enhancement, there does not exist any implicit rules stating which algorithm has to be chosen for what kind of image. By incorporating artificial intelligence techniques, specifically knowledge about how to effectively use these operators, problems can be better understood. We present an expert system with knowledge about enhancement algorithm and context information which are coded as production rules around an expert system shell.

1. INTRODUCTION:

Remotely sensed data obtained from both airborne and spaceborne platforms provide us with an elegant way to monitor the earths surface periodically. A huge volume of data is normally involved in the analysis of remotely sensed images. Human interpretation can extract a wealth of information readily from these images. However, quite a few researchers in earth science may not have adequate knowledge as to which image processing operator or a combination of them has to be used fo rthe application. Different combinations of operators have been shown to give specific improvement empirically for different types of data. By extracting certain statistics from the images and asking the user certain macro level requirement, appropriate combination can be suggested.

Research has shown that expert systems can be engineered to perform inferenced reasoning about simple human visual tasks. However, one of the major problems that worry expert system developers is how to represent image knowledge in an expert system. This problem is often referred to as the iconic to symbolic gap problem (Plenkett 1989). If a large number of images are interpreted pertaining to a particular area they can be used as inputs to related fields like Geographical Information Systems (GIS) where the data bases can be updated periodically and queried as and when required.

The most routinely used approach to combine image interpretation and artificial intelligence techniques is to preprocess the image data and generate various types of labels. Then inferences are performed based on segments rather than on pixels individually. In the present work reported, we have made an attempt to construct a model expert system for image enhancement, in particular. The structure consists of a database of facts, a knowledge base of rules and an inference engine to control the process. The algorithms have been pooled together in a library written in C language.

2. IMAGE PROCESSING

Image processing basically refers to processing of a two dimensional picture information either digitally or optically. Digitally, it consists of two dimensional matrix of numbers represented in the form of bits. Some of the typical problems dealt with remotely sensed data are correction and registration, enhancement, multispectral transformations, classification, image restoration etc. The traditional way of image interpretation of a remotely sensed data using image processing techniques like segmentation and classification lacks two characteristicts viz., (i) integration of geocoded databases and (ii) handling contextual information.

Most of these application subroutines and file data handling routines that are used regularly have been coded in the C programming language and is available in the form of a library. A large number of routines is available for each of the image processing techniques. It normally leads to some confusion among the application scientist as to which operator performs better for his data set. Here we discuss the problems of image enhancement in particular.

2.1 Image Enhancement:

Image enhancement (Jain 1989) is an indispensable image pre-processing function apart from other signal conditioning and image transformation functions. The pre-processed image is segmented either by edge based or region based or texture based techniques. The choice of a particular technique depends on the statistical and structural properties of the area of interest in the image. The image regions can be classified using either bayesian or

Fisher linear discriminant techniques. This gives the overall picture of what goes on in any image analysis problem using a set of IP tools.

Enhancement is performed in order to improve the basic appearance of the image and make it suitable for interpretation. There can be different approaches to achieve it, which includes manipulation of the histogram, reduction of noise, crispening and sharpening the edges. Since the final decision has to be made by the interpreter, frequent interaction with him is required. Histogram stretcbing is one of the most widely used functions for image enhancement.

The results produced by one may not be suitable for the other. Hence if the system is capable of obtaining the image statistics by default stretching the image, it will reduce discrepancies. Once a suggestion/advice has been made by the system it is up to the user to accept it or modify it. The portion of the expert system that performs the enhancement is in two modes. One is the manual mode, where the user is free to do whatever transformation is available and the other is the expert mode. Here the system first provides a default enhancement.

Here we discuss only those approaches where the histogram of the image is manipulated to achieve contrast enhancement. Histogram, provides us with an idea about the distribution of the various gray levels in the image. Histogram of an image can have different shapes viz. symmetric, left skewed and right skewed. The decision of low level parameters are the skewness and the kurtosis values. By making the histogram to occupy the whole dynamic range the contrast of the image can be improved. The number of peaks and valleys in a histogram determine the modes in a histogram. Multimodal histograms have to stretched in a piecewise manner in order to produce a sensible output.

Some typical types of histogram fig. (1a - 3a) and its corresponding modifications are shown in Fig(1b - 3b).

2.2 Expert System (ES) for Image Processing(IP):

The requirement to integrate both declarative contextual information and procedural low level IP function can be best handled through expert systems.

There are a number of papers dealing with (McKeoun 1985), (Hayes-Roth 1983), (Gilmore 1991), (Nazif 1984), Swain 1980), (Showengerdh 1989) the combined use of contextual and statistical and structural data. These expert systems help in the selection of tools from the IP tool box.

Most of them have used the procedural language itself to club contextual information with the statistical figures (histogram parameter) of the image under consideration for the choice of IP operator. In this work we have used an expert system shell, Level 5 object under DOS, working in MS windows environment to handle the knowledge of the contextual information and statistical parameters of the image. The appropriate algorithm for image enhancement coded in "C" is activated through the expert system on the image. The block diagram is shown in figure (4). The shell has capabilities for passing and receiving parameters to a third generation language like "C".

2.2.1 Level 5 Object Expert System Shell:

Level 5 object (Level 5 Users Guide 1990) is an object-oriented expert system development and delivery environment. It provides an interactive, window based user interface integrated with Production Rule language (PRL) also is an application development environment that combines expert system technologies, OOP, RDBMS models, hypertext capabilities, CASE and graphical development and debugging tools. It encompasses the scope of modern application development from rapid prototype to large scale systems development and maintainence.

2.2.2 Knowledge representation:

In totality any image analysis problem has four distinguishing elements: the remotely sensed data; the geocoded database, the contextual information and the image processing tools. In a image processing environment contextual information about a particular object in a scene (image) is a difficult problem to be represented using the all well known paradigms of knowledge representation. viz. as rules or as frames (objects) or any combination of them.

Contextual information is highly declarative in nature i.e., it tells us about "what" of an object. On the other hand image processing algorithms are highly procedural i.e., "how" to extract certain features from an image. There is a missing element between contextual information and image processing algorithms. The missing element is how to combine or intelligently blend contextual and image processing tools. The knowledge based systems can fill the missing gap.

The contextual information (declarative knowledge) about the object in the image and its associated objects is represented in the object oriented representation paradigm. Production rules with both conjuction and disjunction combination are formed using the class-object-property structures of the object and its surroundings. The authors found that in representing knowledge about any image none of the usual paradigms of knowledge representation is sufficient. It is very hard to code the complete information about an object and its associated structures in terms of production rules and objects.

Presently we have found a novel way to solve this problem. We found that a intelligent blend of objects,production rules and hyperegion techniques is a more complete paradigm for knowledge representation. The results of which will be discussed elsewhere.

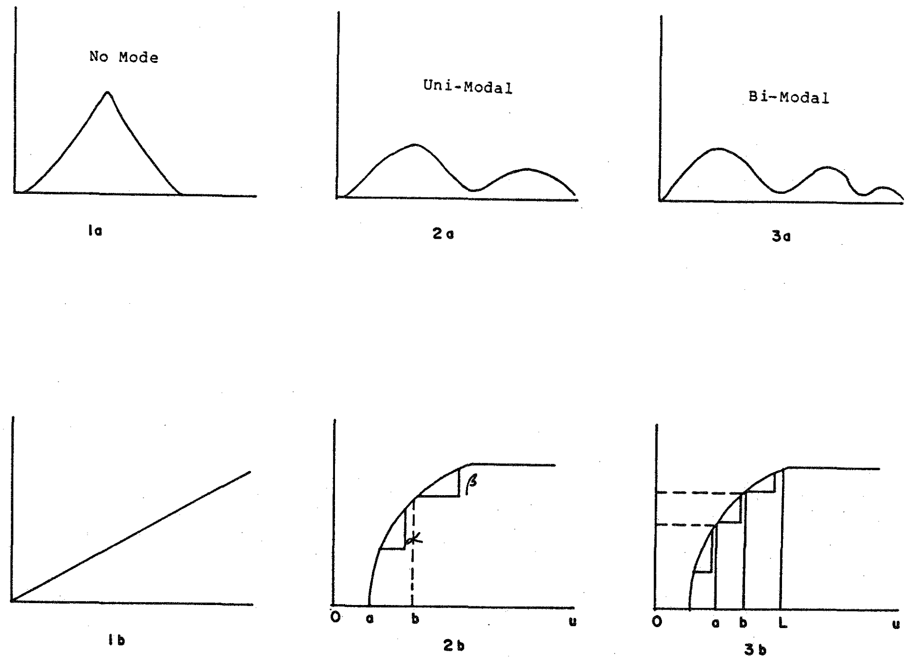

Fig. (1a - 3a) Shows typical types of histograms obtained from satellite images.

Fig. (1b - 3b) Shows the corresponding default stretchings

2.2.3 Inference Mechanism:

The inference strategy followed is purely forward chained (data driven). From the histogram of the image the statistical parameters like skewness, kurtosis and entropy are clubbed with contextual information queried to the user to perform a particular kind of image enhancement algorithm. Confidence factors are attached to the contextual information facts wherever possible. Ancillary information like the sensor details, resolutions, scale, time of day reason about the particular image is being taken care of as a part of contextual information.

3. VALIDATION:

Validation tests of the ES rules against several chips;1 (512 x 512) of various SPOT scenes.The validation required verification that the system is reaching the correct image processing operator based on the statistical figures out of histogram of image and the way the user answers the contextual information queries.

3.1 Application Details:

Typical skeleton of the Production Rule Language(PRL) that gets created out of the Level5 object Expert system shell of the application is shown below. Only two rules depicting the Class-Object-Attribute way of knowledge representation are shown here. They incorporate contextual information and the histogram parameters. The external program activation and parameter passing and receiving are highlighted in these two rules. The complete expert system developed contains about thirty explicit rules for narrowing down the choice of selection of the appropriate histogram modification technique.

```
CLASS image
  WITH context1 SIMPLE
  WITH context2 SIMPLE
  WITH context3 SIMPLE
  WITH context4 SIMPLE
  WITH nkurt NUMERIC
  WITH nskew NUMERIC
  WITH analysis SIMPLE
    SEARCH ORDER CONTEXT RULES DEFAULT
  WITH read SIMPLE

ATTRIBUTE Bimodal Stretch SIMPLE
  SEARCH ORDER CONTEXT RULES DEFAULT
ATTRIBUTE compute histogram SIMPLE
  SEARCH ORDER CONTEXT RULES DEFAULT

INSTANCE the application ISA application
  WITH unknowns fail := TRUE
  WITH threshold := 50
  WITH title display := sample title
display
  WITH ignore breakpoints := FALSE
  WITH reasoning on := FALSE
  WITH numeric precision := 8
  WITH simple query text := "Is it true
that:
  *
is
  *"
  WITH numeric query text := "What is(are):
  *
of
  *"
  WITH string query text := "What is(are):
  *
```

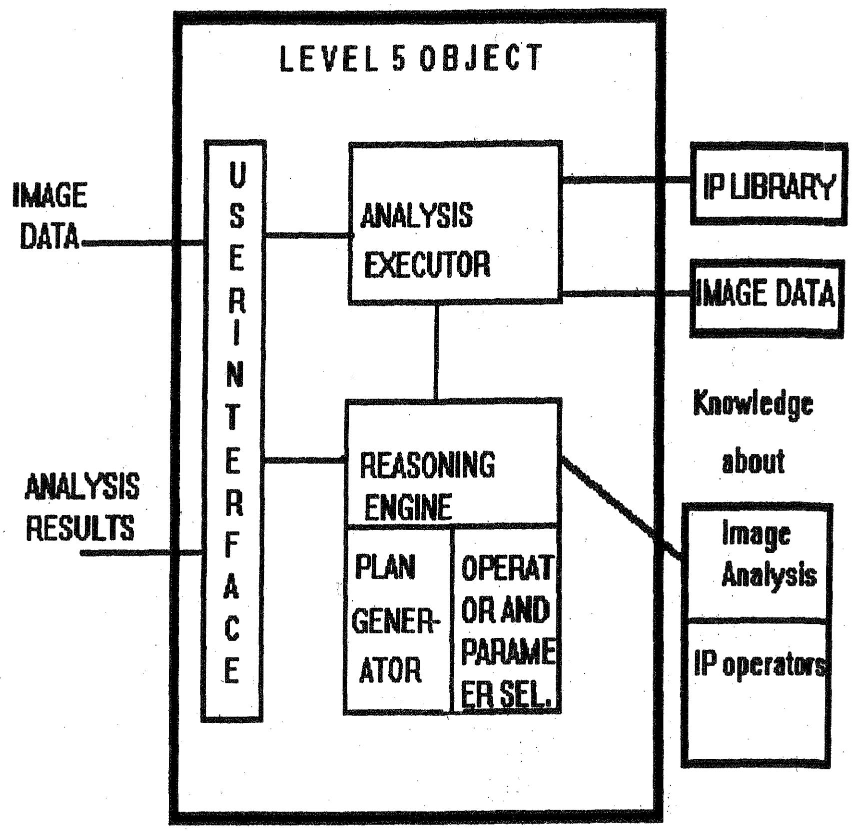

Fig. (4) Expert System Architecture

```
of
  *"
  WITH time query text := "What is(are):
  *
of
  *"
  WITH   interval  query   text   :=     "What
is(are):
  *
of
  *"
  WITH   compound  query   text   :=     "What
is(are):
  *
of
  *"
  WITH  multicompound query text :=   "What
is(are):
  *
of
  *"
  WITH demon strategy IS fire first

INSTANCE sample title display ISA display
  WITH wait := TRUE
  WITH delay changes := TRUE
  WITH items [1] := textbox 9
INSTANCE textbox 9 ISA textbox
  WITH location := 41,39,371,192
  WITH justify IS left
  WITH font := "System"
  WITH frame := TRUE
  WITH scroll := FALSE
  WITH  text := "Typical skeleton  of  the
Production Rule Language(PRL)."
```

```
RULE choosing Bimodal stretching algorithm
IF image.context1
AND image.context2
AND image.context3
OR image.context4
AND  image.nkurt > 2.8 AND  image.nkurt  <
5.0
AND  image.nskew > 0.2 AND image.nskew  <=
1.2

THEN Bimodal Stretch
AND ACTIVATE  "IPU,SERVER,BIMODAL.EXE"
AND image.analysis

RULE computing the histogram
IF image.read
THEN compute histogram
AND ACTIVATE  " IPU,SERVER,HIST.EXE"
  RECEIVE  image.nskew
  RECEIVE  image.nkurt

END
```

4. CONCLUSION:

The automated mode of IP operator selection work exemplified by this ES development will minimize human labor-intensive and varying skill-level elements in image processing applications. Resulting systems should be beneficial for analysis of remotely sensed data. Personnel without specialised academic training will be able to perform image processing tasks.

5.0 REFERENCES

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