An Architecture for Knowledge Based Image Interpretation

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Abstract- In order to cope with the problem of automatic recognition of natural complex objects in their natural environment, we propose an original cooperative architecture based on three specialized knowledge based systems. The first system is dedicated to high level data interpretation. The second one contains the knowledge about the transition between numerical and symbolic data. The third one is specialized in image processing program supervision.

1 Introduction

Our work deals with the problem of automatic recognition of natural complex objects in their natural environment by cognitive vision techniques. In particular, we are interested in the early detection of plant pathologies, for instance rose diseases in greenhouse, by automatic image interpretation. The development of this process is a cornerstone of a large-scale research program aimed at reducing pesticial application.

The data we are working on are two-dimensional macroscopic and microscopic (manified per 60) images of rose leaves. The objects of interest can be fungi or insects. The problem of detection and description is a rich one. Indeed, fungi appear as thin networks more or less developed in microscopic images (figure 1) and as small spots (sometimes not visible to the naked eye) in macroscopic images. Insects can have various shapes and appearances (figure 2). We have to cope with two main problems: the segmentation of the object from its background (vegetal support) and the accurate classification and quantization of the infection.

Due to the various and complex structures of the vegetal support and due to the complexity of the objects of interest (figure 1), the extraction of the pathology and its classification are hard tasks: a purely bottom-up approach is not good enough and *a priori* knowledge about the objects of interest must be used. A hybrid approach combining data-driven and model-driven approaches is considered for the recognition strategy.

Figure 1: Different states of infection (surrounded in white on pictures) and different vegetal supports for a powdery mildew infection (magnification x65)

Moreover, interpretation of images containing several objects implies scene understanding reasoning. Another important point of the presented system is the good use of the scene knowledge and of the relationships between objects to guide the interpretation process.

Our solution is based on artificial intelligence techniques, more precisely Knowledge Based Systems (KBSs). In this paper, we propose a distributed architecture based on three KBSs: a program supervision KBS, a data management KBS and an interpretation KBS.

2 Towards Control Architectures for Image Interpretation

Usually, in the computer vision research area, three levels of abstraction [1] are admitted:

Figure 2: Diversity and multiplicity of insects : Left. An acarid (x 65); Center. A colony of aphids (x 50), Right. Aleurodes and their eggs (x 50)

- The low level which deals with the knowledge about image processing.
- The intermediate level which contains the knowledge about the transition between numerical and symbolic data.
- The high level which contains all the domain specific knowledge: scene and object models.

We decided to build our architecture with respect to these three levels of abstraction not only in an algorithmic way but also in a structural way. So, we decided to build an architecture based on three knowledge based systems. Each KBS is highly specialized for one level. Different control strategies are possible for knowledge based systems: centralized or distributed, bottom-up or top-down, planned or opportunistic. As emphasized, a hybrid control architecture based on the combination of bottom-up and top-down strategies is important. Well known architectures have shown good results: blackboard infrastructure [2] [3] used for a centralized control, multi-agent systems [4] used for a distributed control and some works of our team based on knowledge based systems [5] [6]. We decided to choose a distributed architecture composed of three hybrid centralized knowledge based systems with reasoning strategies (planned or opportunistic) adapted for each level. Instead of having a unique knowledge representation formalism and reasoning mechanism, such a structure allows us to separate the different sources of knowledge and to make KBS highly specialized for a task. KBSs possess other advantages: they allow to exploit expert knowledge and they are easy to maintain. Morever, we have available software engineering tools (Lama platform [7] [8]) for the design of knowledge based system engines.

3 The Global Architecture

In this section, the global architecture of our system is presented. Each level of abstraction corresponds to an independant module as described in figure 3.

3.1 The Interpretation Knowledge Based System

The role of this module is to guide the interpretation process based on the expert knowledge about the different objects of interest and about the relationships between them. A knowledge based system allows us to perform the classification in the same way experts do, using their usual taxonomy. In several domains, a scene and object description can contain different aspects or viewpoints. For instance, in our pathological application domain, pathologists use at least two viewpoints to make a diagnosis: a macroscopic one (coarse diagnosis) and a microscopic one (fine diagnosis). So, we propose a multi-perspective representation system [9]. The different viewpoints may be linked by bridges and the classification process can make good use of these bridges.

Two types of strategies are attached to this module: a top-down strategy and a bottom-up one. The top-down strategy uses the scene model and the object models to:

- separate a problem (an object detection) into sub-problems and build and propagate hypotheses for the expected objects.
- force the information search with spatial relationships between the different objects or parts of objects: spatial constraint propagation.

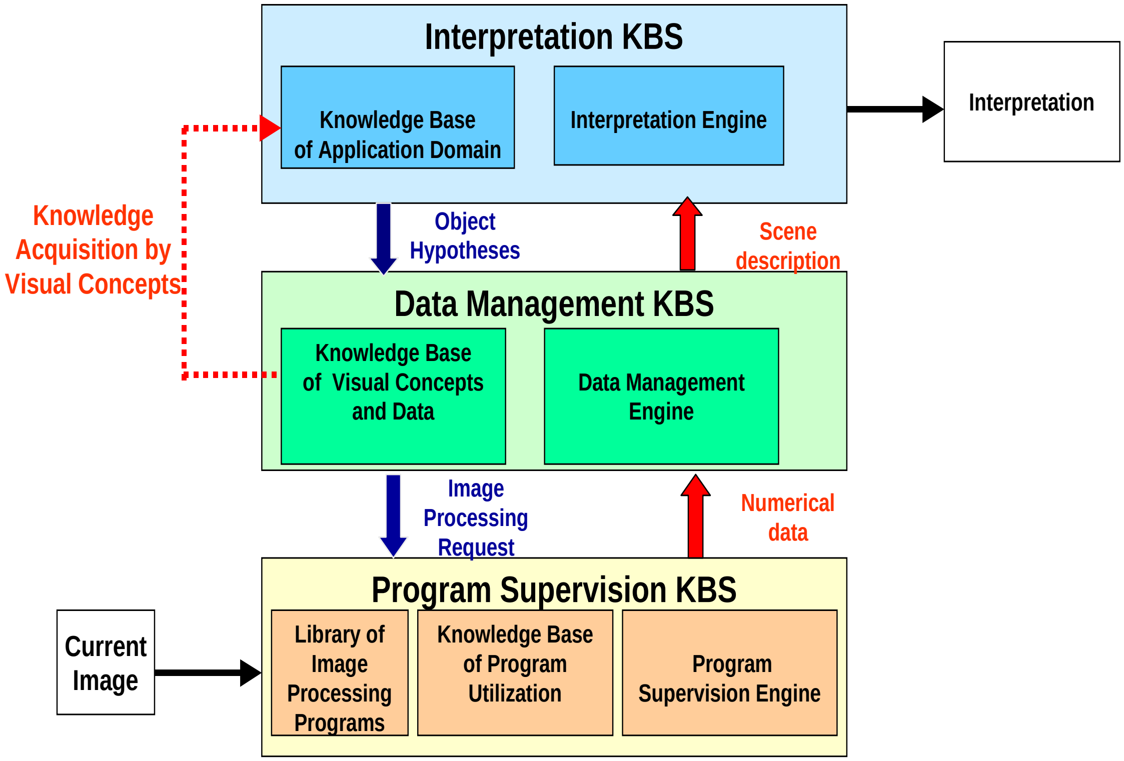

Figure 3: Global architecture of our system

The bottom-up strategy is a classic interpretation strategy: data abstraction using inference rules and bridges between the different viewpoints, matching with a high level class and refinement of the classification.

3.2 The Data Management Knowledge Based System

This module corresponds to the idea that *images have an ontological description of their own, distinct and independant from the domain ontology* [10]. It contains a set of generic descriptive structures and generic spatial relationships which can be used to describe a scene and its complex objects of interest (intermediate description) and which are linked with image segmentation methods. The high level module and the intermediate module share a visual concept ontology [11]. This knowledge base is domain independant. For instance, linear structures are useful to describe objects like fungi in the biological domain and roads in the aerial imagery domain.

From the control point of view, the module must take into acccount the information from the high level system and the information extracted with the image processing system. In a top-down stage, the module must define the area of interest from spatial constraints and build a segmentation or attribute extraction request from the object intermediate description. It corresponds to the mapping from symbolic data onto numerical data. In a bottom-up way, the main task is the mapping from the extracted structures onto symbolic concepts. According to the expected object, this task could be composed or several subtasks like structure grouping, filtering, spatial relationship search or verification,etc.

3.3 The Program Supervision Knowledge Based System

The role of this module is to process images in an intelligent way, i.e. by program supervision techniques [12]. The goal of these techniques is to optimize the use of image processing techniques. This means the automation of the management of an image processing program library by choosing, ordering and executing programs to perform a given task. As described in [13], program supervision techniques are good techniques for the semantical integration of image processing programs independently of any domains or image processing library of programs.

4 Conclusion

Our aim is the automation of image interpretation for complex problems such as natural object recognition in their natural environment. We propose an original distributed architecture based on three hybrid centralised knowledge based systems. This architecture divides the complex problem of image interpretation into tractable sub-problems. Each KBS is highly specialized for the corresponding abstraction level of computer vision. This architecture separates not only the different types of knowledge involved in an image interpretation process but also the reasoning and the control of each abstraction level. Each KBS solves problems in the same way experts proceed. Moreover, this solution is general and independent of the application.

Presently, the work of implementing and evaluating this solution still remains. At the moment, we have only elementary independent pieces of this system: program supervision shells and image processing programs (program supervision module). Morever, the work on biological knowledge acquisition has been done with pathologists [1] (interpretation module). For the intermediate level module, all the work is still to be done.
Furthermore, to improve this solution and to make a generic system, it could be very interesting to add a representation of the temporal dimension and a possibility to reason with temporal data.

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