

## Ontology Based Image Analysis in Autonomous Computer Environment

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### ABSTRACT

Human visual system can interpret and perceive images at different levels where colour, shape, texture and object detection are low level features interpreted well by healthy human visual system, in the same manner detected objects are perceived according to ontological approach.

This paper is devoted to present Content Based Image Retrieval system as continues efforts to bridging the semantic gap between semantic concepts and low level feature of images.

The proposal presented by this paper is focusing on investigating images for conceptual objects topology, by integrating knowledge of multiple Agents collaborated to abstract images into concepts.

Agents individually or collaboratively will promote low level image features to semantic concepts and these concepts will be subjected to certain ontology designed in specific domain to semantically index this image and later to be retrieved according to special query accommodating indexing strategy.

**Keywords:** Agent, Content image, Image Retrieval, Java, Image Indexing, Ontology and semantic concepts

### تحليل الصورة بالاعتماد على خصائص الادراك في محيط الاحتمساب المستقل

#### الخلاصة

نظام الرؤية البصرية للانسان يستطيع تفسير وادراك الصور على مستويات مختلفة حيث اللون والشكل واللمس والكشف عن وجوه وملامح يفسر انخفاض مستوى جيدا من قبل نظام صحي البصرية الانسان ، وبنفس الطريقة التي ينظر الأجسام المكتشفة وفقا لنهج وجودي.

ان هذا البحث يتماشى مع الجهود المستمرة لردم الفجوة بين ميزات الصورة الاولية والمعنى المفهوم من هذه الميزات، حيث انه مكرس لعرض نظام استرجاع صور معتمد على محتويات الصورة وفق آلية تركز على التوزيع الهندسي للكائنات المستخرجة من الصورة والجديد في هذا

البحث هو توظيف مجموعة من الوكلاء (كيانات برمجية) ليقوموا مجتمعين على اختصار الصور بشكل مفاهيم يتم معالجتها فيما بعد .  
ان كل وكيل يقوم منفرداً او بالتعاون مع باقي الوكلاء بعملية ترقية لمميزات الصورة الاولية الى مفاهيم وهذه المفاهيم سوف يتم تسقيطها على خصائص ادراك تم تصميمها لهذا المجال من اجل فهرسة الصور نسبة الى مفاهيمها وبالتالي سوف يتم استرجاعها حسب هذه المفاهيم.

## INTRODUCTION

Images are a major information source in the real world, and represent features of objects like their color, shape and other attributes [1,2]. enormous amount of applications are counting on images as the main interactions with environment such satellite applications, medical applications, security applications and a lot more, the explosive growth of the repositories holding images introduces new challenges such as indexing and retrieving images, where the number may exceed billions when it comes to Web applications, thus a considerable researches have been presented to propose effective mechanisms for image retrieval, mainly two paradigms are adopted: text-based metadata and content-based image retrieval(CBIR)[1].

The purpose of an image database is to store and retrieve an image or image sequences that are relevant to a query. There are a variety of domains such as information retrieval, computer graphics, database management and user behavior which have evolved separately but are interrelated and provide a valuable contribution to this research subject. As more and more visual information is available in digital archives, the need for effective image retrieval has become clear [2, 3, 4, 5]. In image retrieval research, researchers are moving from keyword based, to content based then towards semantic based image retrieval and the main problem encountered in the content based image retrieval research is the semantic gap between the low-level feature representing and high-level semantics in the images [3, 5].

## IMAGE RETRIEVAL METHODOLOGIES

In the past retrieval was done manually by experts who store and index images and they receive requests from people seeking these images, forcing them to search for relevant images using their own knowledge. Today, due to the information boom and the massive number of images been stored and retrieved, an automation methodologies have been the demand [2, 5].

The basic idea of automation methodologies is that documents (i.e., images) are indexed according to pre-defined features extracted from the document itself. Then, given a query that reflects a user's information need, the retrieval system will search the document for relevant match. The main problem affecting the early attempts in designing image retrieval systems was lack of rigorous evaluation [5].

## KEYWORD BASED IMAGE RETRIEVAL

In 1970s, the conventional image retrieval system used keyword as descriptors to index an image however the content of an image is much richer than what any set of keywords can express [2].

Text-based image retrieval techniques employ text to describe the content of the image which often causes ambiguity and inadequacy in performing an image database search and query processing. This problem is due to the difficulty in specifying exact terms and phrases in describing the content of images as the content of an image is much richer than what any set of keywords can express. Since the textual annotations are based on language, variations in annotation will pose challenges to image retrieval [2, 5].

### **CONTENT BASED IMAGE RETRIEVAL**

In 1990s, Content-based image retrieval (CBIR) then has been used as an alternative to text based image retrieval. Unlike keywords-based system, visual features for contents-based system are extracted from the image itself. CBIR can be categorized based on the type of features used for retrieval which could be either low level or high level features. At early years, low level features include colour, texture, shape and spatial relations were used [1, 3, and 5].

Although there are many sophisticated algorithms to describe color, shape and texture features approaches, these algorithms do not satisfied and comfort to human perception This is mainly due to the unavailability of low level image features in describing high level concepts in the users' mind. For an example finding an image of a little boy is playing a ball in the garden. The only way a machine is able to perform automatic extraction is by extracting the low level features that represented by the color, texture, shape and spatial from images with a good degree of efficiency. [4, 5]

### **SEMANTIC BASED IMAGE RETRIEVAL**

In 2000s, semantic based image retrieval has been introduced. This is due to neither a single features nor a combination of multiple visual features could fully capture high level concept of images. Besides, the performance of image retrieval system based on low level features are not satisfactory, there is a need for the mainstream of the research converges to retrieve based on semantic meaning by trying to extract the cognitive concept of a human to map the low level image features to high level concept (semantic gap). In addition, representing the image content with semantic terms allows users to access images through text query which is more intuitive, easier and preferred by the front end users to express their mind compare with using images [3, 4, and 5].

### **SEMANTIC GAP**

Bridging the semantic gap for image retrieval is a very challenging problem yet to be solved [6, 7]. Describing images in semantic terms is an important and challenging task that needed to carry out to fulfill human satisfaction besides to have more intelligent image retrieval system. Human beings are able to interpret images at different levels, both in low level features (colour, shape, texture and Object detection) and high level semantics (abstract objects, an event). However, a machine is only able to interpret images based on low level image features. Besides, users prefer to articulate high-level queries [5], but CBIR systems index images using lowlevel features. Hence, introducing an interpretation inconsistency between image descriptors and high-level semantics that is

known as the semantic gap [3, 5]. The semantic gap is the lack of correlation between the semantic categories that a user requires and the low-level features that CBIR systems offer. [5]

The semantic gap between the low-level visual features (color, shape, texture, etc.) and semantic concepts identified by the user remains a major problem in content based image retrieval [5]. Semantic content representation has been identified as an important issue to bridge the semantic gap in visual information access. It has been addressed as a good description and representation of an image, it able to capture meaningful contents of the image. Current researches often represent images in terms of labeled regions or images, but pay little attention to the spatial positions or relationships between those regions or objects [3, 5].

Spatial relationship is needed in order to further increase the confidence in image understanding. Besides, users preferred to express their information needs at the semantic level instead of the level of preliminary image features. Moreover textual queries usually provide more accurate description of users' information needs [5].

### **SOFTWARE AGENT**

The term 'agent', or software agent, has found its way into a number of technologies and has been widely used, for example, in artificial intelligence, databases, operating systems and computer networks literature. Although there is no single definition of an agent, all definitions agree that an agent is essentially a special software component that has autonomy provides an interoperable interface to an arbitrary system and/or behaves like a human agent, working for some clients in pursuit of its own agenda. Even if an agent system can be based on a solitary agent working within an environment and if necessary interacting with its users, usually they consist of multiple agents [8].

These multi-agent systems (MAS) can model complex systems and introduce the possibility of agents having common or conflicting goals. These agents may interact with each other both indirectly (by acting on the environment) or directly (via communication and negotiation). Agents may decide to cooperate for mutual benefit or may compete to serve their own interests. [8, 9]

### **JAVA AGENT DEVELOPMENT (JADE)**

The first software developments, that eventually became Java Agent Development Environment (JADE) platform, were started by Telecom Italia (formerly CSELT) in late 1998, motivated by the need to validate the early FIPA specifications [8].

Partially funded by European Commission (FACTS project, ACTS AC317) a team composed of Fabio Bellifemine, Agostino Poggi and Giovanni Rimassa were gathered with the good will and dedications to promote the concepts of JADE and its compliant to FIPA. At a certain point it was decided to move beyond a means of simply validating the FIPA specifications towards developing a fully fledged middleware platform. The vision was to provide services to application developers and that were readily accessible and usable by both seasoned developers and newcomers with little or no knowledge of the FIPA specifications. Emphasis was placed on the simplicity and usability of the software APIs [8, 9].

In order to better facilitate industrial involvement, in May 2003 Telecom Italia Lab and Motorola Inc. defined a collaboration agreement and formed the JADE Governing Board, a not-for-profit organization of companies committed to contributing to the development and promotion of JADE. The Board was formed as a contractual consortium with well-defined rules governing the rights and obligations toward generated IPR. The Board is open with members able to join and leave according to their needs. At the time of writing, Telecom Italia, Motorola, France Telecom R&D, Whitestein Technologies AG and Profactor GmbH have all become members of the Board [8].

When JADE was first made public by Telecom Italia, it was used almost exclusively by the FIPA community but as its feature set grew far beyond the FIPA specifications, so did its usage by a globally distributed developer community. It is interesting to note that JADE contributed to widespread diffusion of the FIPA specifications by providing a set of software abstractions and tools that hide the specifications themselves; programmers could essentially implement according to the specifications without the need to study them. This is considered as one of the main strengths of JADE with respect to FIPA. [8, 9]

**AGENT COMMUNICATION**

Agent communication is probably the most fundamental feature of JADE and is implemented in accordance with the FIPA specifications [8,9]. The communication paradigm is based on asynchronous message passing. Thus, each agent has a ‘mailbox’ (the agent message queue) where the JADE run-time posts messages sent by other agents. Whenever a message is posted in the mailbox message queue the receiving agent is notified. However, when, or if, the agent picks up the message from the queue for processing is a design choice of the agent programmer [8].

The particular format of messages in JADE is compliant with that defined by the FIPA-ACL message structure, where each message includes the following fields:

- A. The sender of the message.
- B. The list of receivers.
- C. The communicative act (also called the ‘performative’) indicating what the sender intends to:

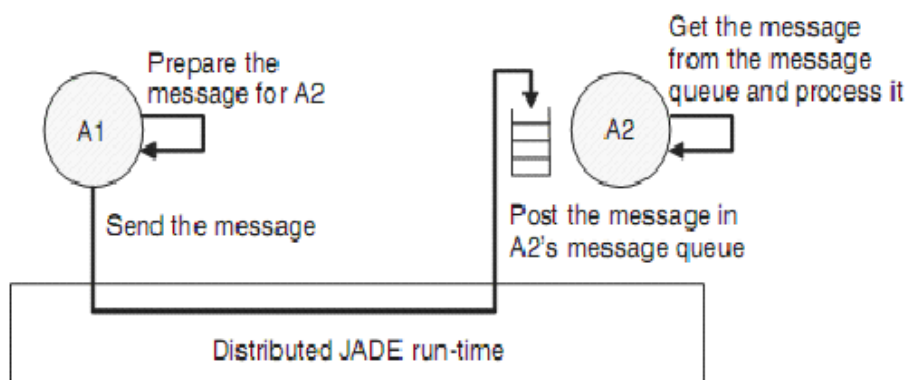


Figure (1) JADE asynchronous message passing paradigm [8].

D.The content containing the actual information to be exchanged by the message (e.g., the action to be performed in a REQUEST message, or the fact that the sender wants to disclose in an INFORM message, etc.).

E.The content language indicating the syntax used to express the content. Both the sender and the receiver must be able to encode and parse expressions compliant with this syntax for the communication to be effective.

F.The ontology indicating the vocabulary of the symbols used in the content. Both the sender and the receiver must ascribe the same meaning to these symbols for the communication to be effective.

Some additional fields used to control several concurrent conversations and to specify timeouts for receiving a reply such as conversation-id, reply-with, in-reply-to and reply-by [8].

### **FIPA CONTRACT NET INTERACTION PROTOCOL SPECIFICATION**

The FIPA Contract Net Interaction Protocol (IP) describes the case of one agent (the Initiator) that wishes to have some task performed by one or more other agents (the Participants) and further wishes to optimize a function that characterizes the task. This characteristic is commonly expressed as cost, but could also be soonest time to completion, fair distribution of tasks, etc. For a given task, any number of the Participants may respond with a proposal; the rest must refuse. Negotiations then continue with the Participants that proposed. The IP is depicted in Figure (2)

The Initiator solicits  $m$  proposals from other agents by issuing a call for proposals (cfp) Call Agent (CA) which specifies the task and any conditions the Initiator places upon the execution of the task. Participants receiving the call for proposals are viewed as potential contractors and are able to generate  $n$  responses. Of these,  $j$  are proposals to perform the task, specified as propose CAs.

The Participant's proposal includes the preconditions that the Participant is setting out for the task, which may be the price, time when the task will be done, etc. Alternatively, the  $i = n - j$  Participants may *refuse* to propose. Once the deadline passes, the Initiator evaluates the received [8].

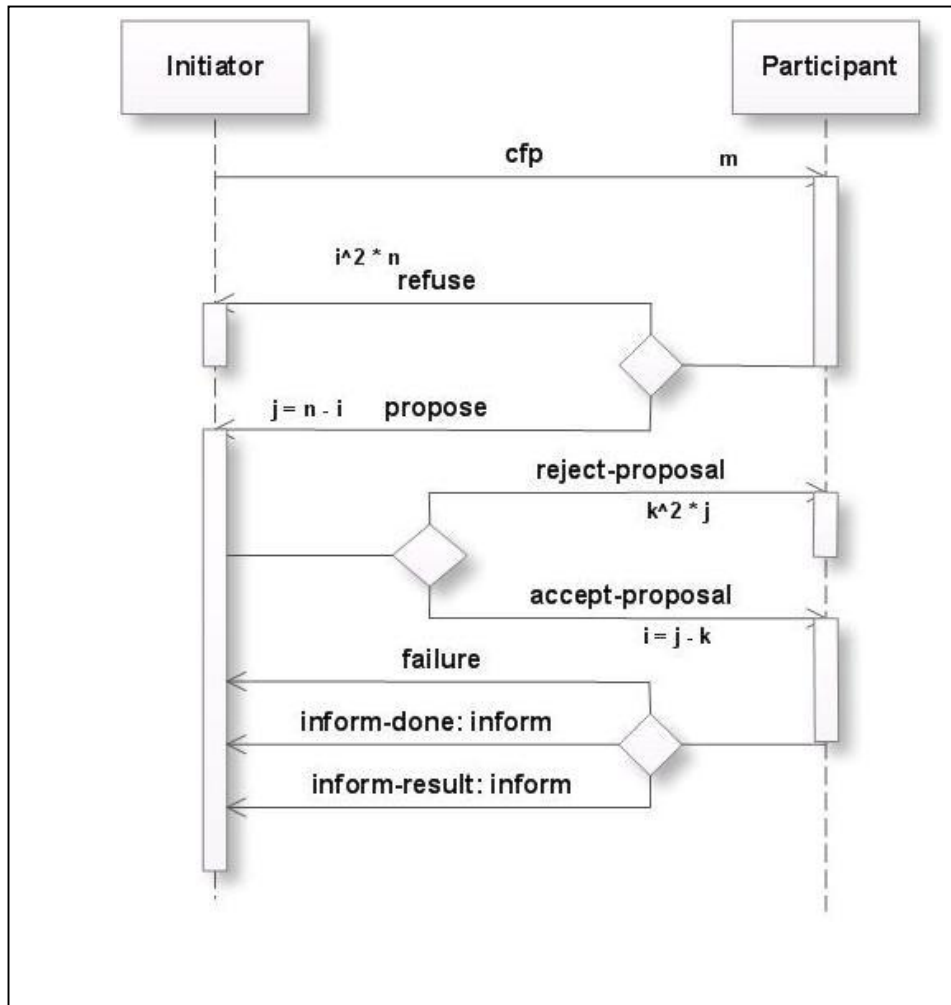


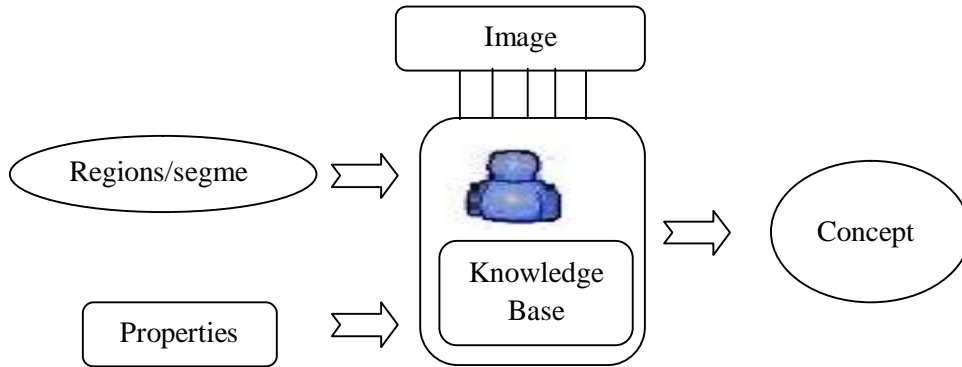
Figure (2) FIPA-net interaction protocol (IP).

**PROPOSED IMAGE RETRIEVAL PARADIGM**

This paper is presenting multi-agent paradigm to facilitate Content Based Image Retrieval (CBIR) system to map low level image features (i.e., colour, textures, shapes and object extraction) to semantic concepts. Basically, content-based image retrieval is deploying sophisticated image processing techniques and algorithms for features extraction which is so hard to be realized, for example wavelet analysis of an image can give great information about that image but it gives no semantic concepts unless its results mapped to.

The proposed paradigm is using the topology of concepts composing the image to index it, in other words image is to be abstracted as conceptual objects distributed over image with certain spatial relationship

Spatial relationship is the main semantic the will be revealed from images and used later to index these images, this approach will be enhanced by using multiple Agents who can perceive image features and promote is to concept. Figure (3) presents the main role for each Agent within the proposed paradigm.



**Figure (3) Agent promoting low level image features to semantic concept.**

This proposal is high level abstracted in term of promoting low level image feature to semantic concept. Agent developer will select optimum methodology to accomplish that promoting at his/her confidence regarding that methodology.

This proposal is using semantic annotation as message format exchanged among Agents where the core strength of this paradigm is to grant Agents the ability to integrate their knowledge in abstracting image to concepts. XML file will be used to represent semantic annotation due to its easiness to be interpreted since tags are used to mark segments and objects. Figure (4) presents the main skeleton of the XML based message format exchanged among agents in the proposed paradigm.

```
<? Xml version="1.0"?>
<Image>
  <object> Table  attributes color="" , " lable="#001" </object>
    <confidence> 80% </confidence>
  <Object> computer label="#002" in_front_of label="#001"</object>
  <Object> person label="#003" in_front_of label = "#002" </object>
  <object> unknown label="#004" on_right_of label=" " </object>
</image>
```

**Figure (4) XML message format representing Semantic annotation for an image.**



An Image is composed of multiple objects and low level features (colors, texture, spatial frequency and many other features). At the semantic level these features are mapped to concepts defined within certain domain (e.g., human face can be abstracted in its composing concepts like nose, eye, mouth ... and so on), thus Image can be represented by:

$$I = (c_1, c_2, c_3, \dots, c_n) = \sum_1^n c_i \quad \dots (1)$$

Where I: Image and  $c_i$  : ith concept within the image.

The topology of these concepts will reflect some important semantic of the image, for example: the image of a class filled with students will have the following topology to reflect one row in that class:

```
<object> person label = "#001" </object>
<object> person label= "#004" on_right_of label= "#001 " </object>
<object> person label= "#005" on_right_of label= "#004" </object>

<object> person label= "# N" on_right_of label= "# N-1" </object>
```

XML example of representing topology of students in class And when topology is defined over domains concepts, a topological query can be constructed, as the following queries:

#### What is behind that car?

This query is represented by the following XML representation:

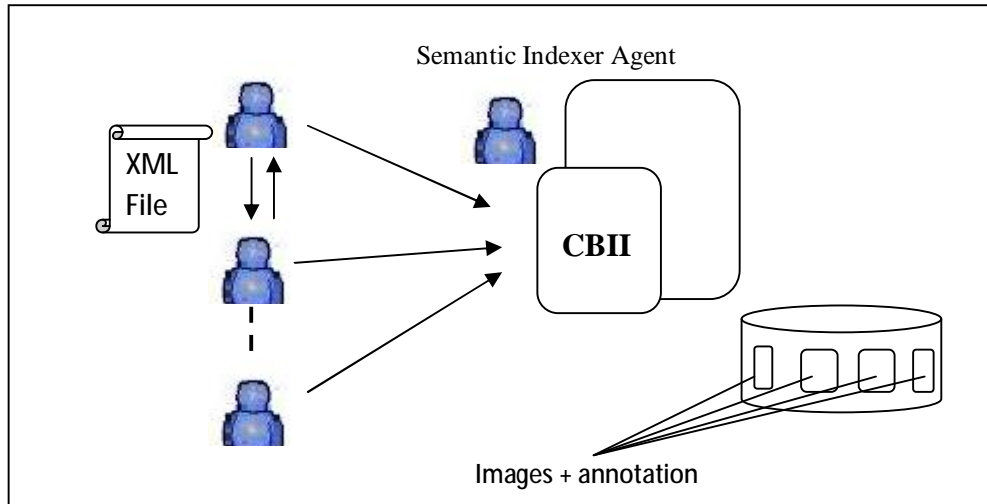
```
<object> car label = "#001" </object>
<object> unknown label= "#004" is_behind label= "#001 " </object>
```

#### What is that object on the left of this person?

This query is represented by the following XML representation:

```
<object> person label = "#001" </object>
<object> unknown label= "#004" on_right_of label= "#001 " </object>
```

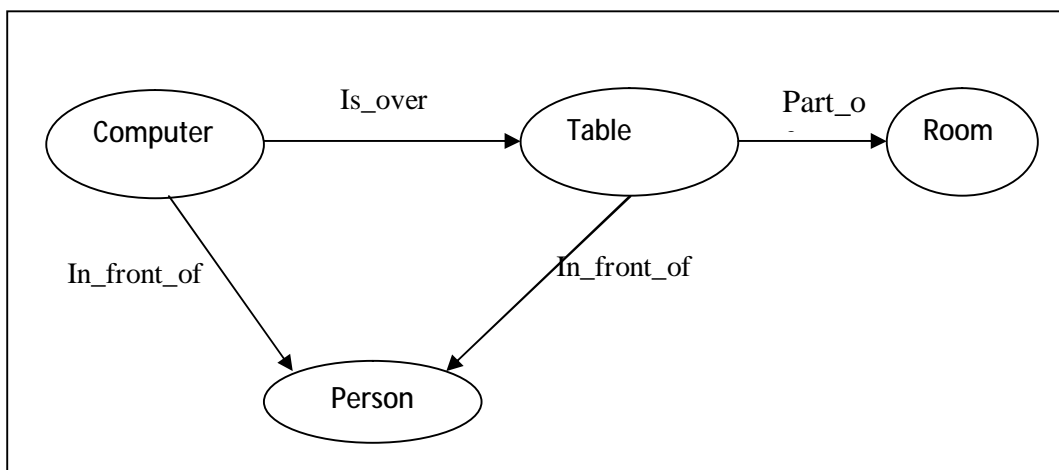
Multi-Agent platform proposed by this paper uses XML topological representation to negotiate Indexing certain image by collaboratively define its concepts, as Figure (5) presents.



**Figure (5) multi-Agent collaborated to abstract Images to concepts.**

CBII: Content Based Image Indexing.  
 CBIR: Content Based Image Retrieval.

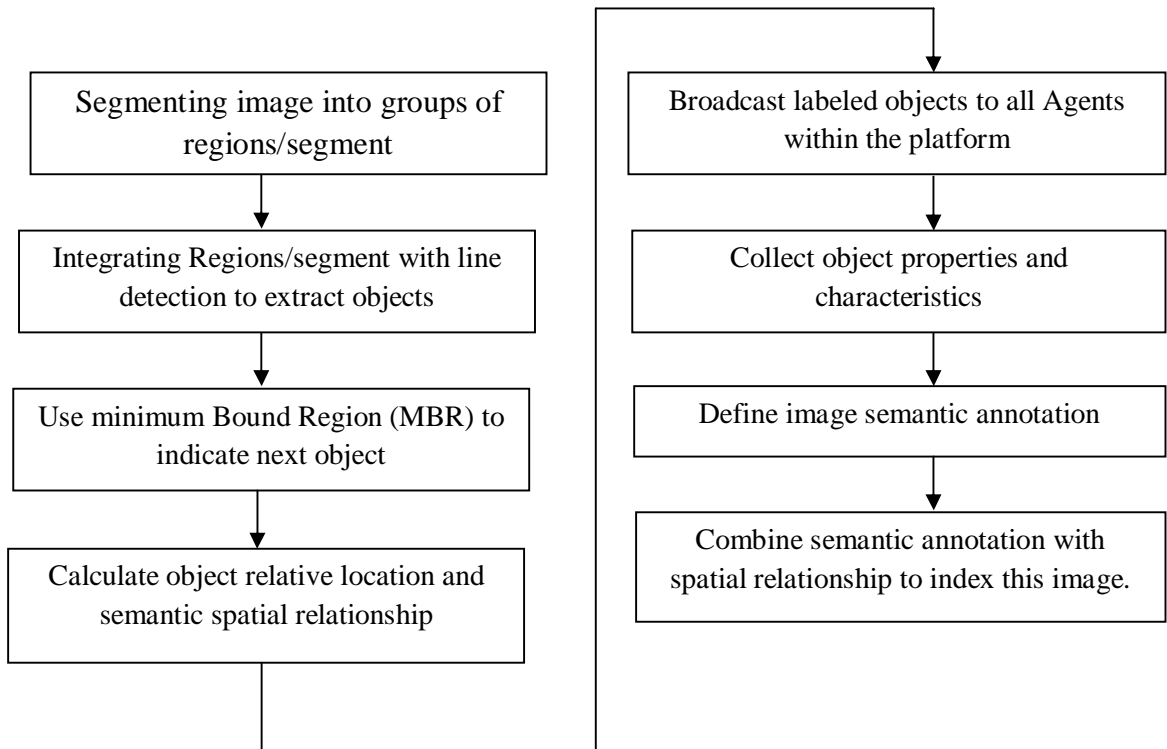
Images are an abstract representation to scenes within a certain domain , thus this paper proposes that the topology of image concepts holds the exact semantic of the Image, for example Figure (6) presents Ontology for a person working on his computer .



**Figure (6) Ontology used by indexer to perceive images in specific domain.**

Figure (7) presents the proposal of this paper where Images are submitted and processed in stages to retrieve its concepts, and later on these retrieved objects are

related to each other through topology. Spatial relationship methodologies have been used by this proposal to build topological view to the image being processed. Spatial relationship should be inform where objects are located as relative to other objects within the image, this will produce more complex concepts.



**Figure (7) Image Concept topology indexer paradigm.**

## CONCLUSIONS

- 1-Automatic Image Retrieving system still needs more methodologies to index images based on their content and extracted features, and this is due to the sophistication of classifying images to their domains. Images contains objects and these objects should be promoted to concepts before building the topology annotation to that image, and this task can't be done unless the domain is determined in the first place, for example images came from satellite can be much similar to images taken to human brain. This makes objects conceptualization more complex task.
- 2-Topology of objects constructing the image can serve excellent in binding low level image features to high level semantics if the view port is evaluated correctly. View port will be the crucial point in determining spatial relationship among objects within the image.
- 3-Socializing image indexing can be integrated to internet search engines to provide accessibility to rich repository on the web, results can be graded relatively to matching scale determined as a collaboration outcome of Agent society.

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