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Artificial Intelligence Techniques in Computer Graphics

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Abstract— Computer is changing our lives & Artificial Intelligence techniques are helping the way for this rapid transformation. the Artificial Intelligence keeps focuses on the fundamental mechanisms that enable the construction of intelligent systems that can operate autonomously, learn from experiences, & solve complex problems as well. This paper helps students to use gain information about AI techniques & its use in various projects. It covers most of key challenges in computing such as how to represent human knowledge & machines thought processes, how to use computational models to understand, to explain, & to predict complex behavior of individual or group, & how to make computers as easy to interact with as people.
The objective of this research paper is to show that the use of Artificial Intelligence in Computer Graphics can greatly improve the obtained results. In this paper we have presented Improvements in three areas of computer graphics : in the scene modeling which can greatly improve the designer's work ; in the scene understanding, which allows the user to well understand a scene by means of virtual camera moving around the scene; & in Monte Carlo radiosity techniques where use of heuristic search which permits to automatically estimate the complexity of a region of the scene to be rendered & to refine the processing of complex regions in order to obtain more accurate images.

Index Terms— Computer graphics, Declarative modeling, Artificial Intelligence

1 Introduction

Computer graphics is one of the three main areas of graphics processing techniques, the other two being Image processing the Pattern recognition. In general manner, computer graphics contains scene modeling & scene visualization. the two important phases of CG scene modeling & visualization, have been first developed independently of each other. Scene visualization techniques developed before scene modeling techniques in the years 1970, because the processing power of computers was insufficient to process very complex scenes. So, it wasn't really a problem to create simple scenes required by rendering algorithms & suitable to the processing power of computers. During this period, very interesting visualization algorithms have been developed.
When, at the end of 70's, computers have became more powerful & people discovered that it was then possible to process complex scene problems with the existing computers & algorithms but it was not possible to get every complex scenes. Computer graphics researchers have discovered that it is difficult to concerned with design a scene by giving the coordinates of points or the equations of curves or the surfaces. Research on the scene modeling has begun & several models have been proposed to improve scene modeling. Presently, there exist well defined geometric models are used into powerful scene modelers & design of the scene is easier than ten or twenty years ago. Even if today's scene modeling & rendering techniques are very powerful, & cases where the available tools are not entirely satisfactory, as well in scene modeling as in scene visualization & rendering. In these cases, the use of Artificial Intelligence techniques can improve the modeling & rendering processes. After having tried to explain why artificial intelligence is useful in Computer Graphics applications of AI techniques in various areas of Computer Graphics will be studied.

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Use of AI in Computer Graphics

The two main areas of computer graphics that are scene modeling and scene visualization are currently well developed & allow to create & display rather complex scenes with a high degree of realism. We are going here to give some examples of non resolved problems in computer graphics.

Scene Modeling

Geometric modeling is not fully adapted to CAD. Main reasons of this are:

- The lack of abstraction levels in the descriptions, due to which some information difficult to obtain,
- The impossibility to use approximate or un-precise descriptions to express un-precise mental images of the user. The user of a scene modeling system would like to express high level properties of a desired scene & would like to let the modeler construct all of the scenes verifying to these properties.

Scene understanding

The complex scenes are difficult to understand, especially scene found on the web, because the scenes are three dimensional & the screen two-dimensional & it is difficult to reach manually a good view position allows to understand the scene.

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Radiosity

In Monte-Carlo techniques are used to compute radiosity, an important number of randomly chosen rays are shot from each patch of scene. These rays permit to regularly sample the scene & to diffuse the energy of each patch. Unfortunately, regular sampling is not always well adapted because most of scenes are not complex. Some regions of the scenes can be very complex while others can be very simple.

3 DECLARATIVE MODELING

Principle

The main purpose of declarative modeling is to overcome drawbacks of classical Geometric Modelling by offering possibility of scene description using properties, which can be precise or imprecise.

Declarative modelling using multiformes

In order to have descriptions at various detail levels, a new declarative modeling technique, called declarative modeling by hierarchical decomposition (DMHD), has been derived. This technique uses top-down hierarchical description & works as follows:
If scene is easy to describe, then it is described by a small number of properties that can actually be size (inter dimensions) properties or form properties. Otherwise a scene is partially described with properties easy to describe & it is then decomposed in a number of sub scenes & same description process is applied to each sub-scene. To express relationships within sub-scenes of a scene, placement properties & size properties are used.

The AI techniques used

There are mainly three artificial intelligence techniques are used in Multi Forms : rules-based systems, constraint satisfaction methods & machine learning. Another artificial intelligence technique, heuristic search, which is also used in Multi Forms but, as this technique is not specifically connected to declarative modeling, scene understanding & scene's complexity estimation in Monte Carlo radiosity. An external description of the scene given by the designer via an interface is converted into a set of Prolog-like rules. The first version of Multi Forms used Prolog-like rules and an inference engine to generate all the solutions for a hierarchical scene's description. The inference engine is able to take into account the hierarchical structure of the description & to generate scenes at various levels of detail. A special inference engine processes these rules & generates all the solutions corresponding to the description. This version of Multi Forms is not very efficient because each property is converted to a rule and, in this manner, a rule can be something very complex which is processed by the inference engine as a whole, with no possibility to be decomposed in order to improve it's processing. A second version of Multi Forms reduced the role of the inference engine & used linear constraints resolution to improve scene generation. This version is more efficient than the first one because each property is decomposed into a set of constraints & resolution
Improvements are applied to each of the constraint. However, used constraints can be expressions of any length & this fact limits possibilities of improvement. In this current version of Multi Forms, each property known by modeler is described by a set of linear constraints. So property can be decomposed & special constraint satisfaction techniques can be used to improves scene generation process. The constraint satisfaction technique used by Multi Forms consists to decompose each constraint describing a property in a set of simple arithmetic constraints & in a set of associated primitive constraints of the form "X in r", where X is the variable that takes values in a finite domain & r is the range.

4 SCENE UNDERSTANDING

In order to understand a scene, designed with the modeler or found in the net, it is then important to choose a view direction
that shows its most important features, such view direction is very difficult to find interactively because a scene is generally three-dimensional while screen is two-dimensional. Thus, it is extremely important that a scene modeler offers an automated computing of a good view direction. Indeed, the modeler has much more information about the scene than the user the could use this information to automatically compute a good view direction. This is especially true for declarative modeling, where the designer has insufficient knowledge of the scene during the designing process.

Static understanding

In order to allow automatic computing of good view direction, we have developed the method using heuristic search. From a criterion of good view it applies heuristic based on the evaluation of some view directions from which it computes the other directions assumed better. These new directions are inferred from the hypothesis that a direction near a good direction is also probably a good direction. To do this, method uses the sphere surrounding scene & good points of view are computed in surface of the sphere by dividing the sphere in spherical triangles. This method was improved by introducing an additional "good view" criterion, which is based on area of projected total visible part of scene. This new criterion is combined with criterion of number of visible surfaces.

Dynamic understanding

The computation of a single good direction is not sufficient, in many cases, to have a good knowledge of a scene. For some of the scenes, several views are necessary to well understand its properties. The work of computing these views can be left to the modeler. The problem is changing a view direction for another one can be confusing for user, especially if new view direction is completely different from previous one. A way to avoid brutal changes of view direction is to simulate virtual camera moving smoothly around the scene. In this camera's movement, sudden changes of camera's path must be avoided in order to have smooth movement of camera, & heuristics must be provided to avoid attraction forces in neighbouring of a good view direction. Camera moves on the surface of a sphere surrounding scene. After first displacement of camera, movement direction is defined by previous & current position of camera. As blunt changes of movement direction have to be avoided, in order to obtain a smooth movement of camera, the number of possible new directions of camera is reduced & only 3 directions are possible for each new displacement of the camera.

One of the 3 possible directions are chosen using heuristic rules taking in to account not only the view direction value of point but also other parameters permitting to avoid attraction points & cycles in camera's movement. As the importance of camera's distance from starting point is inversely proportional to the length of the path traced by camera, the basic heuristic functions computing the weight of a position for the camera on the surface of the sphere takes into account:

• Global view direction note of camera's position (nc).
• Path traced by camera from starting point to current position (pc).
• Distance of current position from starting point (dc).

5 SCENE RENDERING

Improving monte carlo radiosity techniques

The techniques for improving the precision of Monte Carlo radiosity have been developed since 1996. These techniques are based on hemisphere subdivision their main purpose is to estimate visual complexity of a scene from patch the to use this complexity in order to:

-Get more precision in the radiosity computation with the Monte Carlo based algorithms, by shooting more rays in directions when the scene is more complex.

- Get useful image more quickly, permitting to understand the scene to modify it if the visual impression is not satisfactory.

Heuristic search techniques are used to estimate visual complexity of the regions of a scene. the results of these techniques are more spectacular for scenes containing altogether simple the complex parts.

Sampling criteria

In order to make the estimation of visual complexity of a region of the scene precise enough, notion of density of a region have been introduced. the density of a region viewed from patch is the number of objects (patches) contained in region. A hemisphere, divided in four spherical triangles, is associated to each processed patch of scene. At the beginning, hemisphere is divided into 4 equal-sized spherical triangles. Each spherical triangle is then subdivided in independently of the others, according to the retained criterion.

As regions are delimited by spherical triangles in our case, density of region viewed from a patch is number of objects (patches) contained in the triangular pyramid defined by centre of the patch & the three vertices of the spherical triangle. This global density of a triangular pyramid is used in the following manner for computing radiosity, depending on the use of regular & adaptive subdivision.

Regular subdivision of the spherical triangles of hemisphere corresponding to each patch is performed up to a subdivision level defined at the beginning of the process. At the end of subdivision phase, a number of rays, transporting the energy of the patch, are shot in the hemisphere. the number of rays shot in a region delimited by a spherical triangle is proportional to its global density. the amount of energy transported by a ray is proportional to the area of the corresponding spherical triangle.

Adaptive subdivision of the spherical triangles of the hemisphere corresponding to each patch is performed up to subdivision level defined in the beginning of process, only for triangles corresponding to pyramids with global densities greater than a threshold value. the energy diffusion phase for the current patch is performed at the end of the subdivision phase by shooting number of rays in the hemisphere. The number of rays shot in spherical triangle is the same for all spherical triangles. The amount of energy transported by a ray is proportional to the area of corresponding spherical triangle

5 CONCLUSION

In this paper we have presented possibilities of using Artificial Intelligence techniques in different areas of Computer Graphics. The obtained result shows that, in many cases, use of Artificial Intelligence techniques can improve drastically modelling & rendering processes. The main artificial intelligence techniques that are used are rules-based systems, constraint satisfaction methods & the machine learning, in scene modeling; heuristic search & strategy games techniques in scene understanding & the scene rendering. Currently we are working on some other problems whose solution should be improved by use of artificial intelligence techniques. These problems are modeling of non geometric properties of scene, placement of light source according to the expected results & design of scenes with specific properties, to be used for testing new rendering methods.

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