

# Computational Geometry Algorithms in an Educational Intelligent Scenario Management System

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*Abstract:* - In this paper, we present a use of computational geometric algorithms in an intelligent scenario management system. Furthermore, we present the architecture of an intelligent scenario management system, appropriately combined with a computational geometric method, in order to present in a dynamic way the results of an inference mechanism of the above system. As an application of this we introduce a method based on computational geometric algorithms so that the total surface of the proposed logical tree of the proposed system scenario, may be transformed in to a correspondent 3-D geometrical space. The point of this application is to geometrically compare two scenarios, historical for example, of the same issue, in order to support critical thought in the learning process and thus help the educational researcher to extract useful conclusions and generally, achieve a positive educational outcome.

*Key-Words:* - Advanced Technologies in Education, Scenario Analysis, Computational Geometry, Knowledge Representation and Visualization, Modeling History.

## 1 Introduction

Recently there has been an increasing interest in the development of systems which generate dynamic visual presentations, indicating the relations between events, for instance historical, in order to enhance the comprehension of events. These systems support in-depth analysis and estimations of several occurrences/scenarios of an event and may be used increasingly in the learning process.

In this paper we present the use of a computational geometric algorithm in an intelligent scenario management system.

When a researcher (e.g. historical) is called upon to compare two historical scenarios of the same event, he may have difficulty in comprehending their relevance. Therefore, we propose a method that transforms the logical tree representing the scenario's events, into a picture in a 3-D geometric space. This picture is implemented using an appropriate computational algorithm [1,2]. In particular, the logical tree is represented as a convex polytope, which is constructed according to the Voronoi Theorem [3].

This presentation is logged in a supervisory/visual manner based on the different versions of occurrences, for example, historical. Therefore, users are supported in their comparison, as well as in

drawing conclusions. In this paper we used a historical scenario of the Greek war of Independence and we developed two different philosophic approaches to the above scenario in order to test them by the proposed methods.

The paper is structured as follows: In Section 2 "Overview of the System" we give an overview of the scenario system. In particular, we describe in brief a method, based on computational geometric algorithms, and an example of two versions/aspects of the above scenario. Furthermore, in the paragraph "Results" we discuss in detail the presentation system, its functionality and its communication with the intelligent scenario management system. Moreover, we present the educational value of our approach. Finally in section 3, conclusions along with future work are discussed.

## 2 Overview of the System

### 2.1 ISM System

We have developed a methodology for building and analyzing scenarios [4]. The proposed theory has been appropriately extended with a whole knowledge engineering cycle, which must be



forementioned convex polytope, is analyzed as follows:

1. Using the spreading activation mechanism the appropriate values travel throughout the graph and each node Intensity is connected to the next of the tree node until a triangle is formed. In particular, the algorithm starts from the value Intensity (or Tendency) of the central node Outbr, which is connected to the corresponding value of the PsychC node and the LibTr node by forming a triangle in a 3-D coordinate system.
2. The next constructed triangle has at least one common vertex with the previous triangle, for example, with the Natcon, PsychC and Outbr nodes of the proposed ISM system tree.
3. The same procedure is repeated until all combinations of the connected nodes form corresponding triangles.

In this way a convex polytope is formed and has, as its faces, the specific triangles or the intersected triangles. An example of this formation is given in figure 3.

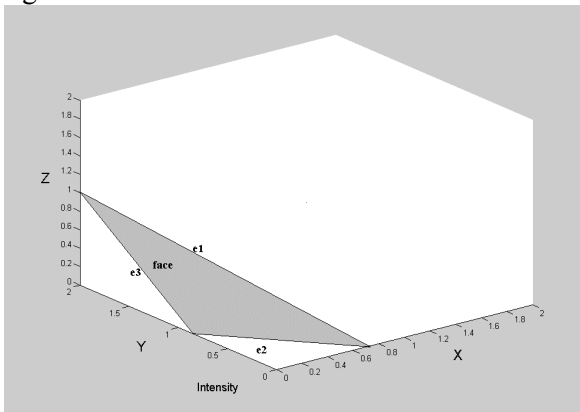


Fig. 2 The 3-D picture of the Intensity of the 3 ISM system nodes.

Taking this into consideration we may consider that the proposed polytope has a specific feature of the proposed ISM scenario tree because on the one hand this is correlated with a dynamic attribute, such as Intensity, and on the other hand, this is correlated with the path of its tree. As a result of this, the computational volume of the proposed polytope may be characterized as a measure of the quantitative and qualitative evaluation of the proposed ISM tree. In accordance with the aforementioned conclusion following proposition may be suggested..

**Proposition:** If we consider two CGA convex polytopes (C3-d1, C3-d2) the intersection of these would yield a new convex polytope (C3-d12), which may be characterized as a significant feature of the proposed ISM scenario.

**Intuitively the above proposition is justified as follows:**

If we assume that:

$$C_{3-d1} \cap C_{3-d1} \neq 0 \quad (1)$$

Then each of the faces of the C3-d12 convex polytope includes a common area values for the corresponding three (3) node sets for each case. In practice this intersection may be characterized as invaluable for a researcher, because it makes it easier to determine the particular differences between two scenarios. A measure of this is the volume of the constructed convex polytope, which may be compared with the value of the central node (OutBr) of the ISM tree (see figure 1). The implementation of the intersection takes place according to the Dobkin et al. algorithm [9].

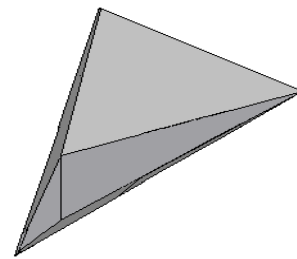


Fig. 3 An example of the constructed convex polytope.

```

C:\MATLAB6p1\work\data_polytopes.m
File Edit View Text Debug Breakpoints Web Window Help
% DATA FILE to specify the X,Y,Z-coordinates of the
% polytope vertices as n-by-3 matrices.
% Coordinates of Polytope 1
X_1 = [ 0.64 0.46 1
        1 0.73 0.34
        0.34 1 1
        1 1 0.73
        1 1 1
        0.46 1 1];
% Coordinates of Polytope2
X_2 = [ 0.73 0.33 0.78
        0.78 0.55 0.64
        0.43 1 0.78
        0.78 1 0.64
        0.78 1 1
        0.55 1 1];

```

Fig. 4 The Intensity Node values of the 6 sets of nodes of the ISM tree as set in a Matlab 6.1 function.

### 2.3 Implementation and example

We have tested many scenarios using the ISM system. In this section we will use one of the initial scenarios we presented, concerning the development of the conditions that brought about the outburst of the Greek war of Independence. This period involves the years between 1700 and 1821 [10].

Using the values of the above characteristics (see figure 4) two (2) characteristic convex polytopes are

formed. It is noted that each historical tree represents a different scenario of the same issue and we used the Intensity nodes exclusively. Finally, we tested the proposed method by submitting the two (2) convex polytopes to intersection (see figure 5,6). Using computational geometric algorithms [11] we computed the volume of each convex polygon and the volume of the common intersection [12]. This procedure was implemented via the software package of Matlab 6.1 and is presented in figure 7.

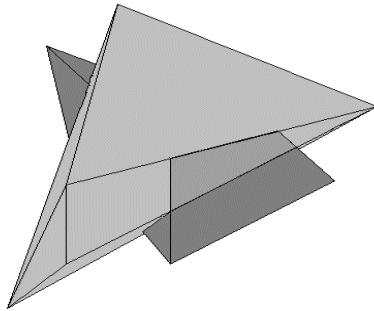


Fig. 5 The intersection of two (2) convex polytopes represents two different historical scenarios of the same historical event

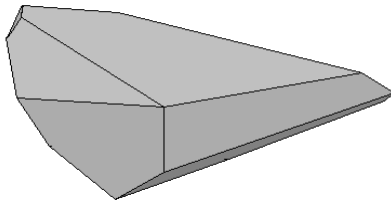


Fig. 6 The convex polytope, which represents the section of two different historical scenarios of the same historical event

## 2.4 Results

In our case the Intensity values of the Outbr node are 1 and 0.78 for the two scenarios of the Greek War of Independence. The corresponding volume values of the convex polygons are 0.047223 and 0.024200 while the corresponding value of the convex polytope  $C_{3-d12}$  is 0.014689. It is clear that the degree of variation for the Outbr node is:

$$\frac{0.78}{1} = 0.78 \text{ .While for the convex polytope case it is:}$$

$$\frac{0.024200}{0.047223} = 0.5125$$

In particular, by analyzing this number we may ascertain that 0.5125 indicates the measure of variation between the Intensity nodes' values in the first scenario in relation the second one. On the other hand, the number 0,78 indicates the dynamic variation of the corresponding OutBr central nodes of the two historical scenarios. In conclusion these numbers may be characterized as specific features of

the proposed method, because these depict the ISM system in two ways: Dynamically (0,78) and Dimensionally in the 3-D space (0.5125)

```

COORDINATES OF POLYTOPE 1:
0.6400 0.4600 1.0000
1.0000 0.7300 0.3400
0.3400 1.0000 1.0000
1.0000 1.0000 0.7300
1.0000 1.0000 1.0000
0.4600 1.0000 1.0000

COORDINATES OF POLYTOPE 2:
0.7300 0.3300 0.7800
0.7800 0.5500 0.6400
0.4300 1.0000 0.7800
0.7800 1.0000 0.6400
0.7800 1.0000 1.0000
0.5500 1.0000 1.0000

VOLUME OF POLYTOPE 1:      0.047223
VOLUME OF POLYTOPE 2:      0.024220
VOLUME OF INTERSECTION POLYTOPE:  0.014689

```

```

COORDINATES OF INTERSECTION POLYTOPE:
0.4942 0.9369 0.8458
0.5117 1.0000 0.9298
0.5500 1.0000 1.0000
0.6065 1.0000 0.8910
0.6467 0.8745 0.6933
0.6544 0.6116 0.8725
0.7253 0.5239 0.8437
0.7473 0.5622 0.8562
0.7565 0.5474 0.7864
0.7800 0.6251 0.7001
0.7800 0.7087 0.6400
0.7800 0.8754 0.6400
0.7800 1.0000 0.8200
0.7800 1.0000 1.0000

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Fig. 7 The program results.

## 2.5 Communication of the systems

### 2.5.1 Input files

The scene and the Computational Geometric Method's module are loaded when the ISM system has calculated the Intensity of the central node. The results of this process are stored in a presentation file. This file and an image database file, are produced by the ISM system, and used as the communication files between the two systems, whenever a new presentation is required.

While the presentation of the ISM system tree is executed the extracted Intensity (or Tendency) of each node are located in a 3-D space. The procedure of the ISM system and the Computational Geometric module are executed simultaneously until the ISM tree system and the intersection between the two (2) scenarios are integrated. In this way the observer may ascertain and learn, in a novel way, basic feature of a historical event and, moreover, to obtain a spherical picture of the variations of historical scenarios.

### 2.5.2 Communication with ISM

When the user asks for the Intensity of a certain node the system calculates the Intensity values of all the intermediate related nodes and stores them, as

well as the code of the correspondent node, in the presentation file. The general architecture is depicted in figure 8.

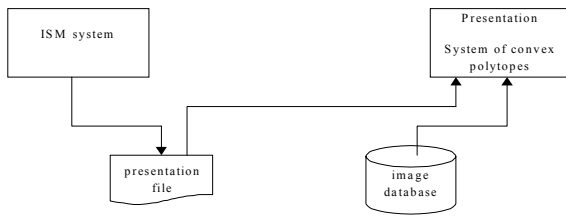


Fig. 8 The overall architecture

## 2.1 Educational value

A lot of the commercial educational software consists of large databases providing static information with a few multimedia characteristics. Such an approach is barely original, with no dynamic elements. Based on the principles of Advanced Learning Theories, the use of visualization in educational programs helps in the understanding and learning of the content. Such systems aim at user friendlier interfaces with highly memorable and illustrative explanations of concepts that increase user involvement. Likewise, our proposed system increases the interest and critical thought of the user by in-depth intelligent scenario analysis or comparing different scenarios or answering questions in a simple way and with the use of computational geometry in a 3-D presentation

## 3 Conclusion

We have presented the combination of the ISM system and the CGA method. The application of this method indicated that while the ISM system produces, following fuzzy logic, connected impact factors of particular events, the CGA method transforms these results and presents them graphically. Furthermore, the CGA method yields a quantitative and qualitative measure concerning the relation between historical scenarios of the same issue. In conclusion, we believe that our approach is a first step towards the introduction of computational geometry in intelligent systems for the reinforcement of the educational learning purposes. Finally, we consider that we have developed a system that may be used in high schools and other educational institutes in order to evaluate the students' interaction with the environment.

Finally, we believe that such a system, which combines Information Technology, Mathematics with History or other scientific areas such as environmental Studies, can be used to develop

appropriate systems that support across-thematic integration in education.

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