Modeling of ATCR Radar Monitor System Using Computer Simulation

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Abstract: This work simulates the radar monitor and a number of flying targets and their appearance on the simulated monitor. The targets are built using object oriented idea, thus a class is being built for the targets so that each target is made as an object which belongs to the same class. A system called Simulated Radar Monitor using hierarchical object oriented timed Colored Petri Nets (SRMCPN) is built. This is a new development for simulating a concurrent overlaid radar monitor which is capable to detect and track multi different targets at the same time improving radar system performance and saving time and cost. This system is implemented under windows environment using Borland C++ programming language.

Keywords: Colored Petri Net, Monitor, Radar

1. Introduction

The simulation of radar monitor is to be made. The Hierarchical Object Oriented Timed Colored Petri Net (HOOTCPN) has all the requirements needed in the simulation process (Balagurusamy, 1997; Maro & Kader, 2001). In reality the radar operation is independent of target flights. Therefore the concurrency concept of the HOOTCPN is applied to simulate this reality. Petri Nets have proven to be a useful formalism to express concurrency. Problems related to concurrent processes are getting more and more important to be managed, i. e. solved (Daniel & Heilko, 1999). Concurrency is implemented using threads, and any application that uses multiple threads can be called a multi-threaded application (Kayshav, 1997).

2. Theoretical Principles

A. Determining Target Position (Lee & Alexander, 1999; Louise,1999; Troy, Raymond & David, 2000)

Once a target is detected, the next step is to pinpoint the precise location of a target. This position provides the user with the distance (range) to the target and its direction.

Range: The distance to a target is determined by measuring the round trip transit time of the signals between the radar and the target.

Direction: For most radar, the direction to a target is measured in terms of the angle between the line of sight to the target and some reference coordinate system. Most of the time, this angle is divided into its horizontal (azimuth) and vertical (elevation) components and are measured based on the direction where the antenna is pointed (see figure 1). By knowing the range and direction of a target, a radar system can use this information to track the target location as needed.

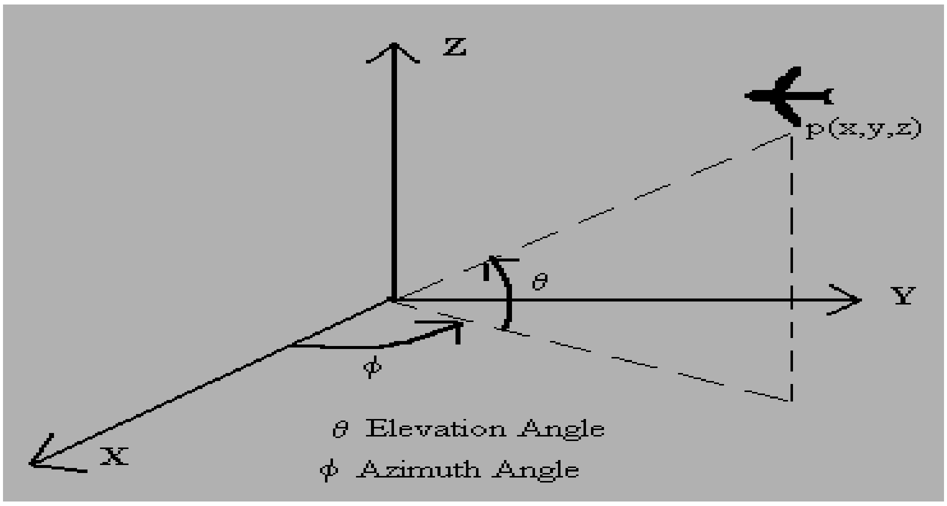

Figure 1: Target position determination

B. Radar Target Geometry

Having justified the straight line approximation of the ray trajectory one arrives at simple configuration for the radar target geometry, shown in figure 2, on the basis of which one may derive most expressions for the computation of the geometrical quantities for the relevant propagation (Rohan, 1983).

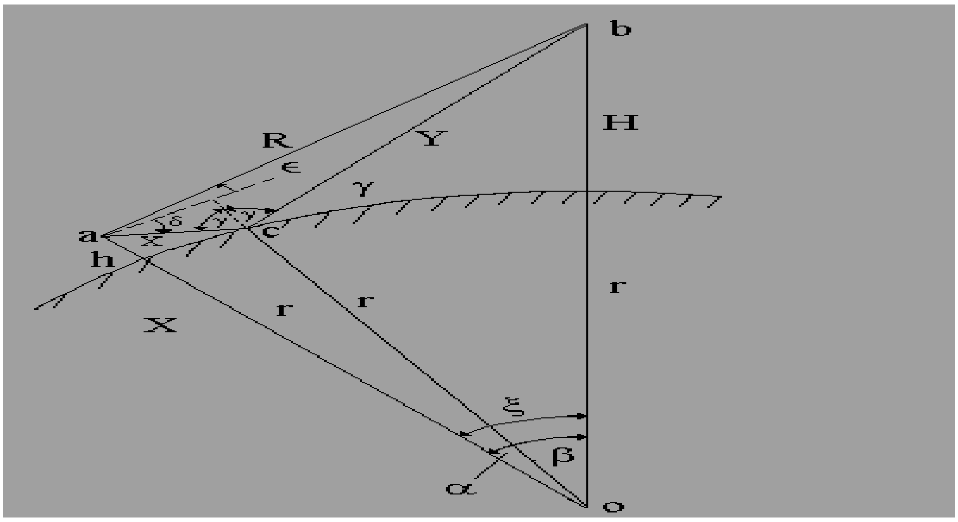

Figure 2: Radar target geometry (Rohan, 1983)

The derivation of radar target geometry was explained by Al-Samerai (1988).

For all these results to be true, it is necessary that the range R not exceed the distance to the radio horizon of the radar, which will be true provided that [Peyton Z. P., 1998], the target range R is to be:

$$R = 4.12(\sqrt{h} + \sqrt{H}) \tag{1}$$

Where h is the radar antenna height and H is the target height .

3. Simulation of Radar Monitor

The structure of the SRMCPN system is shown in figure 3. Each part of the system will be explained in the following subsections

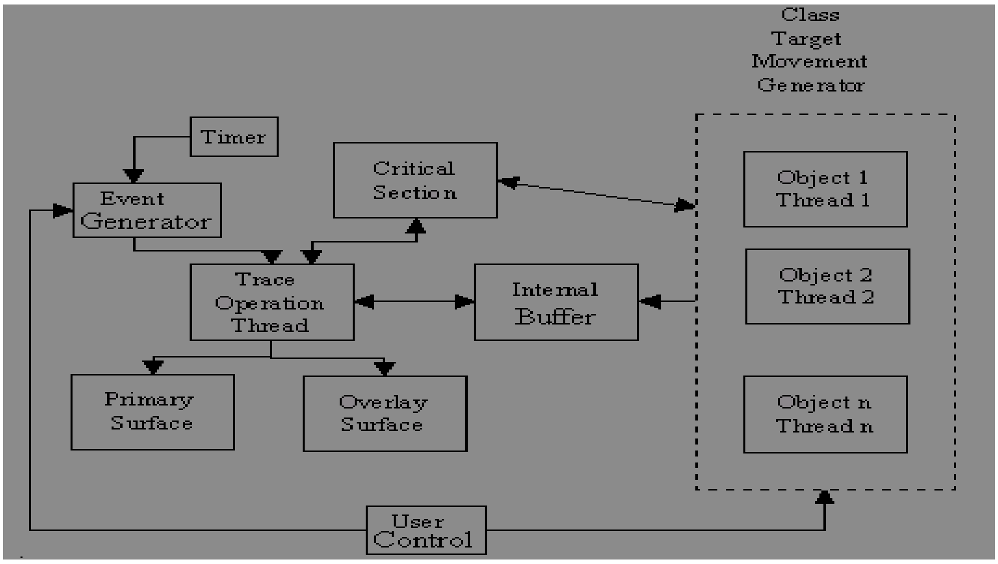

Figure 3: Structure of the SRMCPN system

A. The timer

The timer is the synchronizer of the whole system; it controls the speed of the trace and the execution and suspension of the threads.

B. Event Generator

The event generator reads the time from the timer continuously. By using this event generator it is possible to generate an event every 5 microseconds.

C. Critical Section

The important feature of the system is that, when one process is executing in its critical section, no other process is to be allowed to execute in its critical section. Thus, the execution of critical sections by the processes is *mutually exclusive* in time (Silberschatz & Galvin, 1998; Metev &Veiko, 1998).

D. Internal Buffer

The internal buffer is a 600x600 matrix, where all the information before they are written to the overlay surface, are written to the internal buffer. The internal buffer is a shared resource between the targets threads and the trace thread.

E. Trace Operation

The designed monitor has a maximum range of 300 km. Depending on this principle; the monitor is divided into 12 range rings. Every range ring equals 25 km. The monitor provides zooming facility, and this facility gives 10 zooming areas. The tenth zoom makes the maximum range to be 30 km.

F. Target Movement Generator

The target movement generator is built as a class so that a number of objects can be generated during the operation of the system. Each of these objects when created will be created as threads. The next target position is calculated by using one of the following equations according to the user requests:

$$y = x^4 - x^2 \quad (2)$$

$$y = 2x^4 - 2x^2 + 1 \quad (3)$$

$$y = x^4 - 2x^3 - x^2 - 2x + 2 \quad (4)$$

$$y = 10\mathrm{Sin}(x - \mathrm{Sin}(x)) \quad (5)$$

4. Results & Discussion

A. Implementation of the SRM System

The application of the SRM system is shown in the following figures (4 to 7). In figures 4 to 7 the results of applying equations 2-5 respectively are presented. Figures 8 and 9 show two zooming steps of the SRM. Figure 10 shows the four targets on the SRM in addition to the presence of the map on the primary surface.

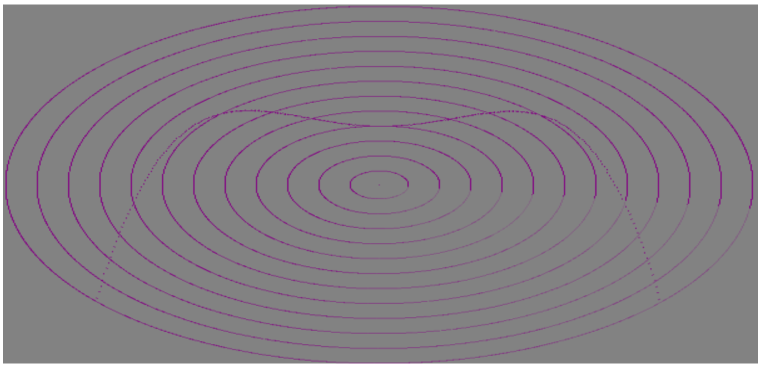

Figure 4: Application of $y = x^4-x^2$

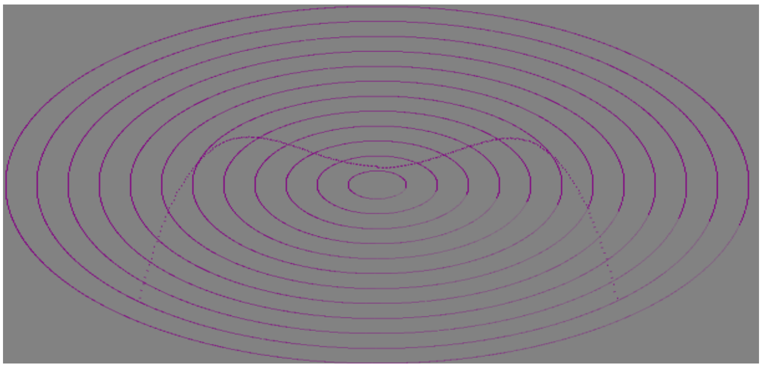

Figure 5: Application of $y = 2x^4 - 2x^2 + 1$

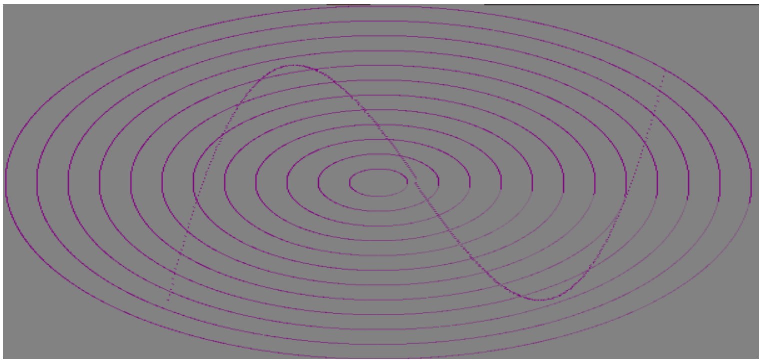

Figure 6: Application of $y = x^4 - 2x^3 - x^2 - 2x + 2$

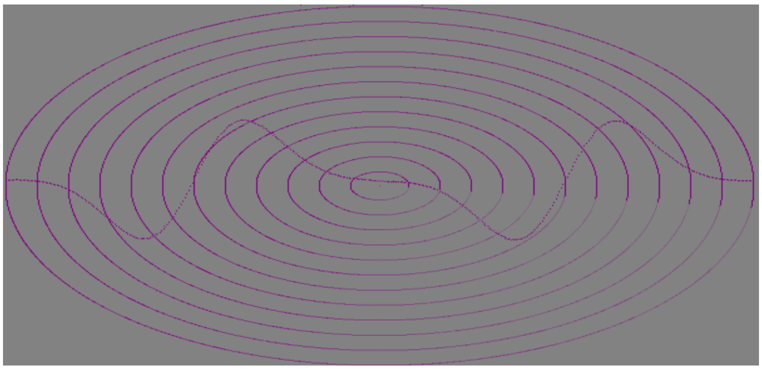

Figure 7: Application of y = 10Sin(x-Sin(x))

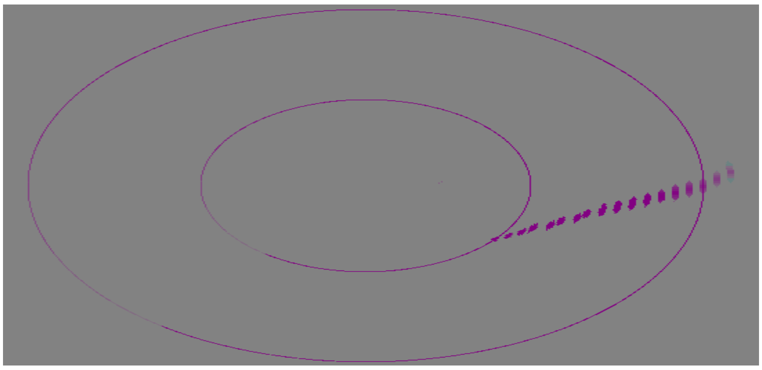

Figure 8: Target detection at zoom step 9

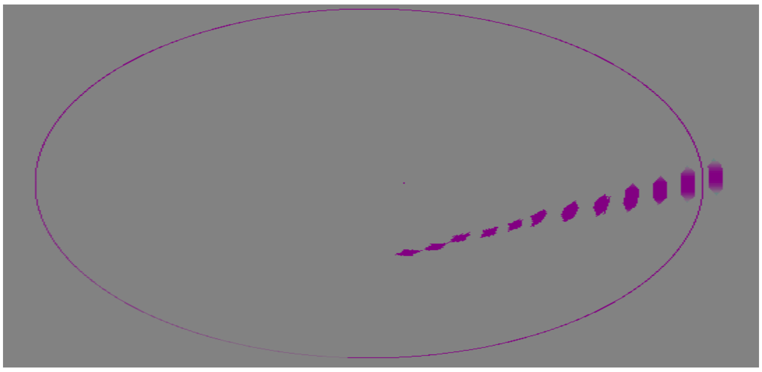

Figure 9: Target detection at zoom step 10

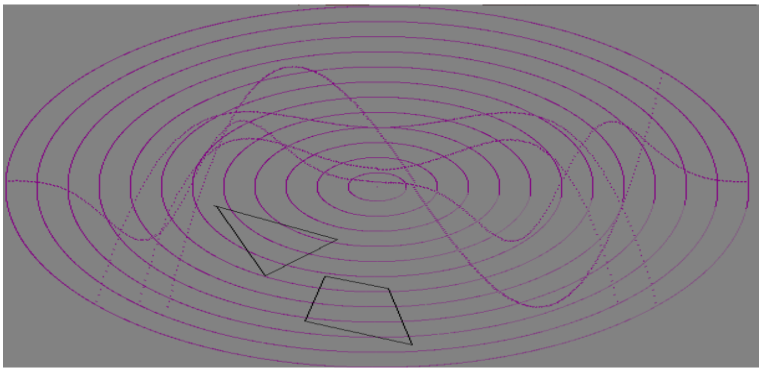

Figure 10: Four targets with map

B. Discussion

Firstly, representing the time was a need, because the radar monitor trace rotates at fixed speed and takes an amount of time to complete the rotation. The CPN has the ability to represent time and to operate accordingly.

Secondly, in reality when there are a number of airplanes flying in the air, then these airplanes are independent of each other, where each airplane has its own pilot who takes decisions independently of other pilots (except for the rules of flight). This fact was implemented by first building a class for the targets, and creating objects of this class, the objects were the same page instances but with different target parameters, and secondly the created objects where operated as threads. In addition the radar monitor was created as a thread to operate independently of the targets. Here the CPN has the ability to represent concurrency in addition to the object-oriented concept.

Thirdly, when modeling is in progress the model may get big and becomes a huge complex model. This problem is solved by using the hierarchy available in the CPN. The decay of the targets are apparent with the trace movement, this decay can be made independent of the trace which will make the fading smoother (Skolnik, 2001; Robert, 2010).

5. Conclusion and Recommendations for Future Work

The use of overlay surface in addition to the primary surface in drawing saves a lot of time and calculations.

2. The modeling of the SRM which is constructed by this software gives high flexibility for any changes in the future contrary to a display built by hardware.

3. The use of concurrency concept offers the facility that if any of the target objects has stopped its operation because of any error like (division by zero), the operation of the other target objects and trace will not be effected.

The SRM can be improved to include a third dimension i.e. becomes 3D to visualize the clouds, fog, rain and wind in addition to 3D earth topography.

6. Acknowledgment

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