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Introduction to Agent Based Simulation in Flexsim

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ABSTRACT

Agent based simulation has it's roots in theoretical mathematics since the 1940s. The concept has it's basis in the idea of large systems of interacting machine automata which can replicate, learn and reproduce. The early adoption of the technique in the simulation field has been evolutionary and has developed and matured significantly in recent years. Several influential studies in the field have occurred since the 1970s, leading to adoption into the field of general simulation as what we now know as agent based simulation. This paper discusses agent based simulation in the context of one such general purpose simulation system, flexsim. Flexsim is a visual object oriented simulation tool which has several core abilities of virtual reality, discrete event modeling, a built in rapid prototyping language and full integration with c++. Agent based simulation with the flexsim's o-o capabilities is discussed.

HISTORY

The origins of ABS date as far back as the 1940s when von neumann and stanislaw ulam developed the concepts of cellular automata - machines, which had a key characteristic of being able to reproduce themselves and act independently according to their defined behavior. In the 1970s john conway developed the influential ‘game of life’ - a game whereby cells on a grid are given simple rules to govern each turn of the game. The result was some surprisingly unpredictable behavior on the grid which is one of the first examples of system emergent behavior. Later in the 1980s craig reynolds devised a computer simulation named ‘biods’ where automata in 3d geometric space where given simple rules governing their movement with respect to each other. When the simulation was run, the resultant behavior of the system as a whole far surpassed the complexity of the rules governing each of the individual automata in the system. Thus the simulation became a compelling example of system emergent behavior. In the decades that followed, the concept of focusing on agent based simulation became something of a discipline in the world of simulation. In the present day, ABS is becoming integrated into general purpose simulation tools in combination with other modeling concepts such as process based modeling

AGENT BASED MODELLING

ABS has no strict universal definition as yet, but is becoming a mature technology. It is essentially an object oriented approach to modeling. The behavior of the system to be modeled is automata-centric as opposed to process centric. An often cited feature of objects in an agent based simulation is their ability to learn during the simulation thus altering their behavior dynamically during a simulation run. A key feature of agents is their

awareness of their environment. An agent is designed to react dynamically to it's environment (the simulation model including other agents) and it's knowledge of it's environment is limited to a given scope so as to model it's localized observation of it's surroundings. A powerful feature of ABS is the phenomenon of emergent behavior. Emergent behavior is system wide behavior of the model as a whole which could not necessarily have been predicted in terms of the behavior of the individual agents.

APPLICATIONS

Applications of agent based simulation include:

- Social systems
- Ecology
- Warfare
- Disaster response
- Biology
- Traffic systems
- Human operators

Technology available today in ABS includes freely available software, university developed systems and commercial software. Tools available include: flexsim and anylogic which are both commercial products; mason, netlogo, repast and swarm, to name a few.

AGENT BASED MODELLING IN FLEXSIM

Flexsim DS is an object oriented simulation tool. Thereby is naturally well suited to ABS. It also possesses special features for modeling large volume systems, either through it's built in modeling constructs, or c++ for especially demanding agent based models. In Flexsim DS the ability to combine any number of models together provides unlimited scalability, such that in principle, any size of agent model can be constructed. This can be especially important when agent based models have the possibility to become computationally intensive. Flexsim is able to represent agents with objects and can describe the state models of each agent object in it's own modeling language or c++. The 3D virtual reality environment of flexsim allows the agents to operate in a detailed high fidelity world where geometry, shapes and motion exist. Rapid development of agent models is facilitated through the built in flexscript language engine which does not require compilation steps, and if more simulation execution power is required, the same code can be promoted seamlessly to c++ for optimal performance.

SUMMARY

ABS is a non-process approach. That is to say that from the standpoint of the analyst, the real world can be broken down into autonomous agents primarily, as opposed to processes through which entities move. ABS complements process based modeling -- in the respect of being able to produce a representation of the real world, which may be better suited to the system or parts of the system being modeled than process modeling.

Since the two techniques can be used in the same simulation, the two approaches can be used to model parts of the system that may be better suited to one approach or the other. In the respect that agents are essentially objects, any object oriented simulation modeling tool can be used to implement an agent based model. However, one possible drawback of agent based modeling is the possibility of large numbers of events arising in the simulation model, as behavioral responses may occur continuously as the simulation runs, compared with the a process based model who's events are typically spread out over time. ABS is a powerful approach from the modeler's point of view as it requires only a localized view of how objects behave in a model as opposed to the modeler having to provide details about how the system is expected to perform as a whole. Because of the ability of ABS to model situations where process definition is not well suited, it is likely to be adopted increasing both on it's own and in combination with process simulation.

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