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SIMULATION WITH DISCRETE AND CONTINUOUS MATHEMATICAL MODELING

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ABSTRACT

Technological advances in computer hardware have made the use of desk-top computing widespread and universal throughout the business world. Today's managers have instant access to market information. Because of this, there has been a change in the speed of the decision input output process. However, the pedagogical computer simulations utilized by most Schools of Business have not changed with the advent of the new informational technology. This paper presents a comparison between discrete and continuous simulation and recommends the latter be incorporated into marketing business games.

INTRODUCTION

Technology In the form of computer power and information has changed the methods by which business is conducted in the United States. Since 1980 the unit sales of advanced personal computers, work station minicomputers and super minicomputers have experienced phenomenal growth. Also experiencing large increases in growth are the unit sales of personal computers, minicomputers and large mainframes, supercomputers. [7] Coupled with this is the growth of software. In 1981 personal computer software sales were approximately half a billion dollars and by 1989 sales are projected to be 10 billion dollars. [5] Another tool providing the business persons with information are the already existing 2400 databases plus the new ones being created every month. According to Daniel Seligman, "Lockhead, Mead, Dow Jones, Reader's Digest, H & R Block and the SEC are among those trying to change the world by pushing on-line databases." [11] The final example is a cover story from Business Week [6] entitled, "Information Power -- How Companies are Using New Technologies to Gain a Competitive Edge".

All of the above mentioned articles concerning the increasing use of desk-top micros, computer terminals, computerized telephone modems, on-line databases and user-friendly software have evolved the business world into a today happening event. In other words, managers no longer have to wait for quarterly reports, monthly reports or even weekly reports. Today there is instant accessibility to market data on the manager's desk via the desk-top terminal or micro computer.

The volatile business environment has always fostered changes in the teaching community, but, for one reason or another, Schools of Business have this time lagged behind. What is needed is for School of Business classes to be caught up with the hardware and software changes of the previous five years. Specifically, this paper is an admonishment for current computer simulations that are time fixed format games. These are games that have decisions based on a predetermined fixed decision interval, for instance, quarterly or monthly reports. Marketing games aren't realistic when decisions can only be implemented once a month and market data can only be retrieved or outputted once a month. This does not represent the workings of today's business world. Students should be subjected to the same rigors that they will experience after graduation. This means data input and output continuously when students want it, not when game designers allow the students to input and output at some arbitrary discrete time format.

The <u>purpose</u> of this paper is to illustrate the techniques of continuous and discrete type computer simulation. Specifically, this paper will extend the merits of continuous type simulation for marketing business games. The <u>importance</u> of this paper is to emphasize that teaching methodology changes are needed in higher education business courses because of the technological environmental changes which have occurred in the business world. The need for this paper is to inform current and future model builders to utilize, when applicable, continuous mathematical modeling.

It is necessary to clarify a few terms. A model is a representation of an object, system or idea in some form other than the entity itself. [121 Mathematical modeling is an attempt to describe some part of the real world in mathematical terms . a model whose parts are mathematical concepts, such as constants, variables, functions, equalities, inequalities. 19] Lastly, a simulation is a model of some situation in which the elements of the situation are represented by arithmetic and logical processes that can be executed on a computer to predict the dynamic properties of the situation. [4]

DISCRETE SYSTEMS

A discrete system is one in which the stated van- able(s) change only at a discrete set of points in time. [1] However, few systems can really be classified as discrete or continuous. Few systems in practice are wholly discrete or continuous, but since one type of change predominates for most systems, it will usually be possible to classify a system as being either discrete or continuous. [8]

Figure 1

Discrete

Frequency Distribution

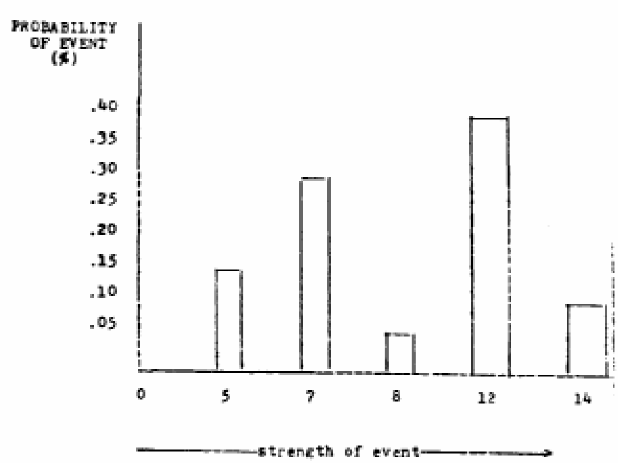
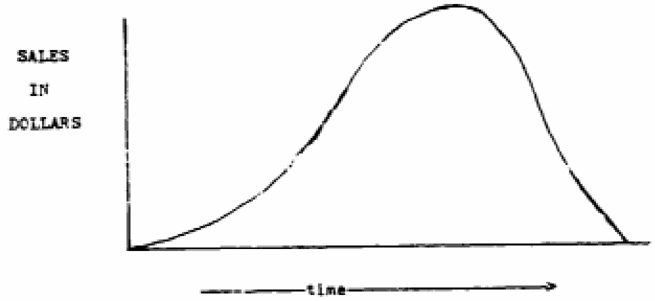


Figure 2
Product Life Cycle



In this section an explanation of a discrete simulation of a product's life cycle will be presented. A product's life cycle was selected for the following reasons: (1) the nature of demand flowing through time, (2) during a product's life, managers (and students) constantly require market data, (3) the data should be available quickly or instantaneously and (4) managers will then modify their decision variables to adjust to changing market requirements. Before examining a product life cycle, examples of discrete simulation will be presented.

Figure 3
Discrete Simulation of a Product Life Cycle

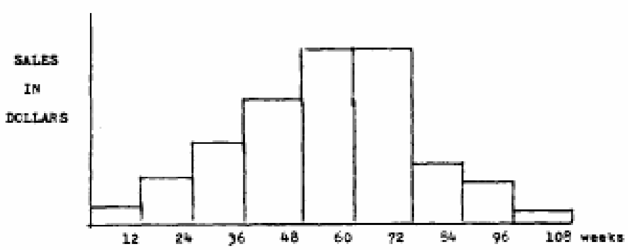


Figure 1 illustrates the probability distribution of an event's strength. Basically, an event of strength 5 has a 15% chance of occurring, an event of strength 7 has a 30% chance of occurring, an event of strength 8 has a 5% chance of occurring, and so forth. If the strength of the event is for instance a 5, this could represent the following hypothetical situations, (1) 5 customers walking into a store, (2) 500 units of a product being purchased, (3) 5 people seeing and remembering an advertisement, (4) a 5% share of market, (5) a $5 price of a competitor's product, (6) 5 products being shipped on time, (7) 5 new government regulations being enacted by the United States Congress, (8) 5 more Japanese competitors entering the market place and (9) a 5 million dollar profit. This is discrete type logic in mathematical modeling and computer simulation.

Figure 2 presents a typically shaped product life cycle, while Figure 3 presents how most business games simulate the product life cycle. Upon comparing Figure 2 with Figure 3, it is readily visualized that discrete simulation games do not accurately represent the continuous business system being modeled. The reasoning for this is the aforementioned characteristics of most business games, the fixed time format. The example presented in Figure 3 is for a product life cycle of approximately two years. The business game simulating this product has nine decision inputs with each input equally twelve weeks. Although fixed format games do well in simulating some parts of the discrete business system, they do not accurately represent continuous state systems.

Upon further examining Figure 3, it is noted that students can only obtain information at exactly week 12, week 24, week 36 and so forth. Students may also only modify their decision variables at week 12, week 24, week 36 and so forth. Is this a realistic marketing computerized simulation game designed to pedagogically represent the real business world? No.

CONTINUOUS SIMULATION

Continuous simulation is the name given to the use of a digital computer to solve models with continuously changing states. [2] Most of the continuous simulation literature concerns itself with full wave rectifiers [3] and radio-active decay [10] or models that flow through time. These are the usual applications of continuous simulation, but continuous simulation can also be applied to business games.

This section will present two continuous modeling techniques which can be incorporated into marketing simulation games. They are continuous compressed time and continuous extended time simulation games.

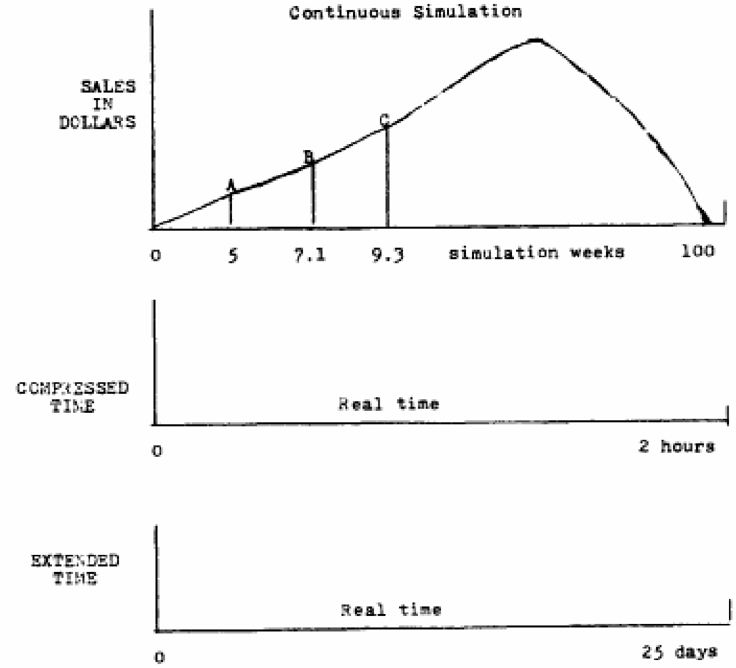
Both of the modeling techniques are interactive in nature. The games are played interactively on computer terminals, continuously. That means from simulation time period 0 to week 100, the game is constantly being played simultaneously by all of its participants without a break in the action. In real time this could represent one hour, two hours, or three hours. This interactive type simulation is accomplished by a computer capable of accessing files through I/O devices and communicating the results (market data, market variables and market demand) to each student Inter- acting and participating in the marketing game on computer terminals.

Figure 4 illustrates how a product's life cycle can be simulated by continuous techniques. When examining Figure 4, it is seen that students are able to obtain information and modify decisions at any time during the simulation, for instance at simulation time period A, B and C. This corresponds to week 5, 7.1 and 9.3 respectively.

Referring again to Figure 4, it is seen that for the continuous compressed time simulation examples the game is played interactively on computer terminals for two hours. In the extended time simulation example the game is played interactively for twenty-five days. For twenty-five days, how are the students kept on the terminals for twenty-five days?

Figure 4

Continuous Simulation



In the extended time simulation technique, students are able to access the terminals whenever they want during the twenty-five day period. Students participating in the simulation can modify variables and retrieve market data for any simulated week during its corresponding real time.

The twenty-five day continuous extended time simulation is played in the following manner. Students play the game simultaneously and all start at the same exact time. Students are able to access the simulation game once a day, many times a day, or not at all. The participants decide. The participant can access the terminal 5 times or 250 times during the twenty- five day period. The computer does keep tract of the time intervals between each access and then calculates a corresponding rate of demand. Through the use of a time system procedural file program, the continuous extended time simulation will periodically update participant files for competitive market data each day.

RECOMMENDATIONS

Discrete type simulations will and should be used when the system that is to be modeled contains discrete type events. However, when the system contains elements that move through time, then continuous simulation is recommended for the model builder of computer simulations. It is hoped that this paper will be a springboard in the development of new continuous type simulations.

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