December 2006

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ABSTRACT

Interpretation and audit of financial information is a significant undertaking that must rest on a fuller understanding of the firm and its operations. A pictorial representation of firm activity offers promise for supporting this requirement. After reviewing the literature related to visualizations, we describe the design of an animated version of the operating cycle. It assists users in developing an intuitive sense about the operating cycle itself, while exploring and visualizing how firms at various stages of growth, sustenance, and decay are affected by specific operating decisions. Findings from the accounting and information systems literatures were used to drive the design of the representation. This resulting system adds depth to traditional accounting representations by conveying information about the momentum of the firm's activities, the rate of change at which various operating activities are occurring. The animation facilitates identification of backlogs or breaks in operating processes, thus increasing understanding of the firm's operating health.

Keywords

Animation, information representation, visualization, interactivity, simulation, accounting information systems

INTRODUCTION

Little has changed in the graphics we use to represent key management data since William Playfair published his *Commercial and Political Atlas* in 1786. Meanwhile many areas of science and engineering have seen interactive computer graphics transform the way they explore and present data. Whether it is a weather pattern or a molecule, a tsunami or an as yet unbuilt building, computer graphics are being used both to explore and to explain complex systems. In this paper, we describe the design of Business Animator, a computer-based interactive animation for representing many dimensions of an organization's operational performance.

RESEARCH ON ACCOUNTING REPRESENTATIONS

Humans have long developed accounting systems for recording their transactions with one another. The double entry system in wide use today was published by Fra Luca Pacioli in 1494. The financial statements that are produced by this system have been refined over the centuries and formalized by rules and regulations, yet understanding how the financial statements represent a firm and its operations is an ongoing challenge. The interpretation of internal financial information presents challenges for both managers and auditors. Managers need to be able to identify potential operational problems as soon as possible. Auditors need to be able to identify weaknesses in underlying data as well as in the reports generated.

Mathematical tools have been widely used for both internal and external financial analysis. The most common tool is ratio analysis which provides useful information, but interpretation is neither automatic nor instantly accessible. Analysts and researchers have frequently attempted to ease ratio interpretation by some sort of presentation (charts, graphs and even faces) other than columns of numbers. Another stream of literature has focused on what data might be missing in the traditional financial information. Ijiri developed the notion of triple-entry bookkeeping as a way to address a weakness in the current system, its inability to represent rates of change in financial variables and the forces behind those rates (Ijiri, 1982).

In this project we integrate and extend these streams of research around the problems of representation. We create a more complete picture of the firm than can be conveyed in a single face or static graph, while at the same time creating a more concise representation of multiple dimensions than would be available in an array of charts and graphs. Our design takes advantage of technological developments to exploit the power of animation.

THE PSYCHOLOGY OF VISUAL REPRESENTATION

A basic principle of distributed cognition theory is that a cognitive task includes both internal and external representations, which together contain the abstract structure of the task (Zhang and Norman, 1994). In order to perform a cognitive task, such as making a business judgment or decision, people need to process information distributed across the internal mind and the external environment. Whatever external representations we create will have to link to the internal representations that people produce. Computational offloading, re-representation and graphical constraining are three characteristics that can be used to explain the connection between internal and external representations (Scaife and Rogers, 1996). According to visual computing theorists and dual processing theory, a basic way to effectively facilitate the connection is to improve the visibility of the information embedded in the data (Stanovich and West, 2000; Friedhoff and Peercy, 2000). Indeed, a good external representation will be one that links naturally to the internal representations that people are capable of forming, thereby supporting their overall cognitive processes.

TEXTUAL VS. GRAPHIC REPRESENTATIONS

The first issue we face is whether textual or graphic representations should be favored given the task of understanding operational activities in an organization over time. Tables and graphs are both used to represent large data sets. Many studies have explored the features of these two representations and the conditions under which each is superior. A series of experiments summarized by Benbasat *et al*. concluded that graphical presentation was more useful in searches for optimal solutions, but that tables were more useful in tasks that required determining exact numbers (Benbasat, Dexter and Todd, 1986). In the study that is most closely related to the current research, Volmer compared graphical presentations of the financial ratios of the firm with numerical financial information, and concluded that graphical information not only saved time, but was also were considered important to providing clear insights into the financial position of the firm, thus improving communication (Volmer, 1992). This literature provides a basis for optimism that a graphic representation will be useful given our objective of developing an understanding of the dynamics of an organization through time.

THE POWER OF ANIMATION

A second issue is whether the graphic representations employed should be dynamic. There is a general belief that animations not only improve users' understanding, but also make interfaces easier and more enjoyable to use. This belief has been tested in many studies, although the results have not produced a consensus. In a review, Tversky, *et al*. argued that empirical studies have not provided strong evidence that animated graphics out-perform static graphics, but they are particularly promising in conveying real-time changes and temporal-spatial reorientations due to people's natural cognitive correspondences based on the congruence principle (Tversky, Morrison and Betrancourt, 2002). Prior research suggested that animations can enhance comprehension, problem-solving, learning and presentation persuasiveness (Large, Beheshti and Renaud, 1996; Mayer and Sims, 1994; Morrison and Vogel, 1998). Movement and interactivity are two important attributes of animations which affect the early preconscious stages of visual processing, and further facilitate the effective use of visualization by increasing the amount of preconscious processing (Stanovich and West, 2000; Friedhoff and Peercy, 2000). Since our visualization is for use with data that have a strong temporal character, and in an environment where there will be repeated use and learning, we have reason to anticipate that animation will be useful.

THE CYCLE MODEL

Visual models of the firm's operating activity have been proposed as a way of helping managers and accountants understand the critical components of a firm's operating cycle. Boland proposed the cycle model, the most basic version of which presents the operating cycle of a firm as three interacting cycles: an input cycle, a transformation or value-adding cycle, and an output cycle (Boland, 1983). A manufacturing firm provides the most accessible interpretation of these activities. The model assumes an existing business with the ability to purchase raw materials on credit. In the input cycle, a company acquires raw materials from its suppliers. In the transformation cycle, value is added to the raw materials through the manufacturing process to create inventory to sell to customers. The output cycle represents the sale of the finished goods to customers of the firm. This stylized representation, the operating cycle, represents the day-to-day operations of the firm. For a firm to be able to operate, however, requires capital investments in property, plant, and equipment and the funding to make those investments. The simple model shown assumes an existing firm with adequate resources for its current level of operations. The possibility of changing those levels of resources requires appending two additional cycles to the model, an investing cycle and a financing cycle.

The overall activities of the firm represented in this model should seem somewhat familiar to financial statement users since it conforms roughly to the structure of the cash flow statement and its labeled sections. This stylized representation illustrates most of the flows presented in the financial information currently produced by firms. However, in a static form it does not allow the user to measure characteristics of the flows occurring within the individual component cycles.

ADDING DYNAMICS TO THE CYCLE MODEL

With the advent of more powerful and accessible computer animation, the cycle model can be adapted to provide a dynamic representation of the firm's activities. Business Animator utilizes control and display technologies developed for the real time music industry (Max from Cycling 74). Our goal is to provide a program through which managers and analysts, using sophisticated controllers (knobs, sliders, pedals, etc.) are able to develop an intuitive sense about the cycle model itself, while exploring and visualizing how firms at various stages of growth, sustenance, and decay are affected by specific operating decisions. The animated version of the model incorporates a holistic vision of what characterizes the entire organization. The animation portrays temporality, allowing the theoretical construct momentum to be captured and depicted as the cycles.

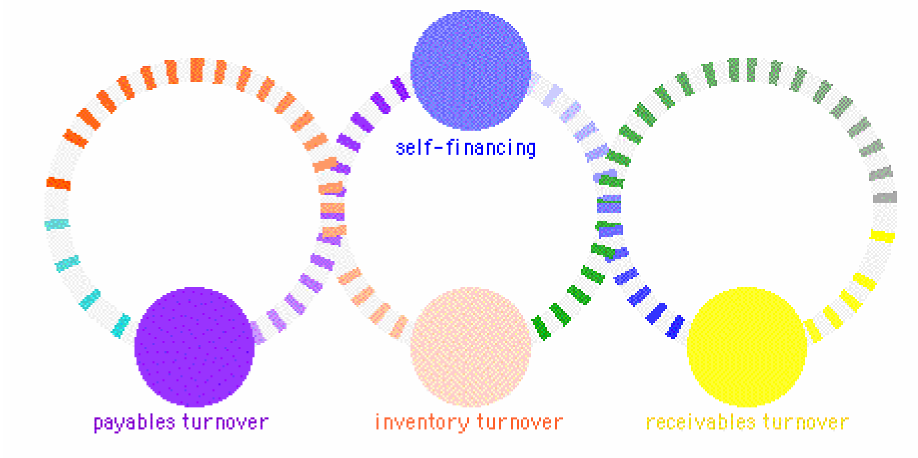

Figure 1. The Screen Shot of the Dynamic Operating Cycle

The rules that govern transition and rates of change in a business are embedded within the financial outcomes as Figure 1 shows, some of which are measurable by ratios that can be generated to help understand a period of operations. For example, the change in brightness of small orange circle and contrast in speeds of orange and green paths are used to represent inventory turnover; the change in brightness of small purple circle and the contrast in speeds of purple and turquoise paths are used to represent payables turnover; the change in the brightness of small yellow circle and the contrast in speeds of yellow and blue paths used to represent receivables turnover. These turnovers reflect how quickly and efficiently inventory is managed, turned into finished goods, and converted ultimately to cash to be repaid to suppliers and reinvested in the business. The change in brightness of small blue circle and the contrast in speeds of blue and purple paths are used to represent self-financing. All of these financial ratios are critical to explore the health of a firm's operating activities.

The user can determine starting points or baseline acceptable conditions for a particular firm, creating inputs commensurate with specified ratio relationships. The program then runs through specified numbers of cycles. The user can interact with the program using sliders and knobs to change parameters for simulations. The animation, using movement and color, indicates whether the operation remains smooth or whether problems occur. Backups at nodes are indicated by both a slowdown in cycle movement and by gradually changing colors. In order to show a more complete picture of a firm's financial status, we have included dynamic representations for some other financial indicators from balance sheet as Figure 2 shows, such as total assets, capital, and debt service. All the indicators shown were demonstrated to be important for accounting information based decision making, particularly useful for bankruptcy judgment (Mackay and Villarreal, 1987; Umanath and Vessey).

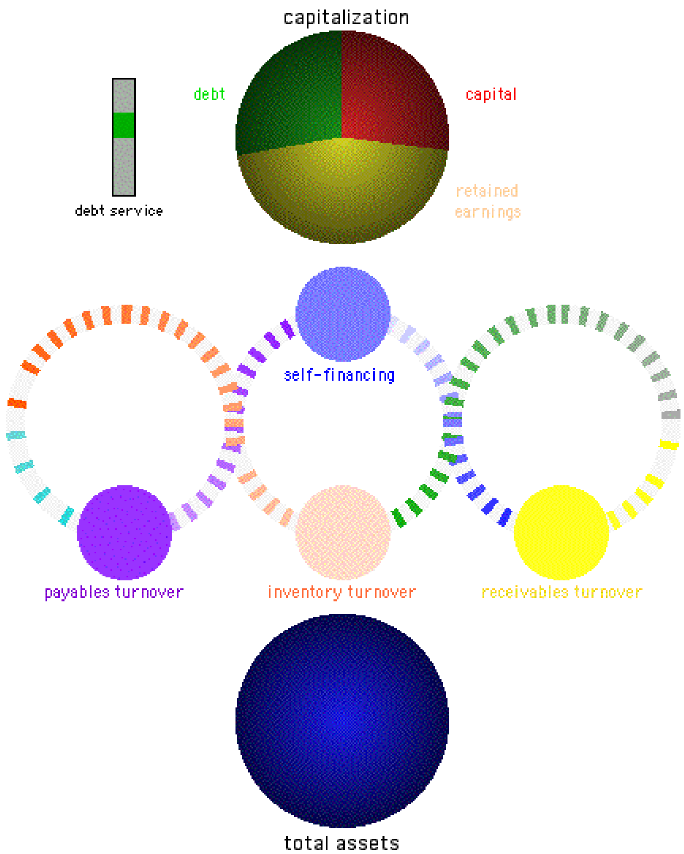

Figure 2. The Screen Shot of Business Animator

We have begun to explore how backlogs in either inventory flow or cash flow within operations appear when animated. Utilizing the accounts receivable and inventory turnover ratio relationships of a large Fortune 100 firm as a base, we have created contrasting data situations that lead to differences in momentum at different points of the operating cycle: slow receivable turnover with fast inventory turnover, fast receivable turnover with slow inventory turnover, slow turnover in both, and fast turnover in both. These data are fed into the model via a simple text file, and the operating cycle runs for as many cycles as desired.

IMPLICATIONS AND FUTURE RESEARCH

The development and use of the tool described in this paper has the potential to significantly improve understanding of the operating condition of a firm, from both external and internal perspectives. The cycle model of firm activity can be applied to *ex post* financial information to aid in the interpretation of ratios. It can quickly highlight areas in which the firm's operations were not as efficient or as effective as possible. The model can also be applied *ex ante* as a planning tool to identify potential pitfalls in operations, such as bankruptcy prediction. This sort of simulation is greatly enhanced by the use of understandable knobs and sliders so that a user can quickly change inputs and observe the results. Growth plans and other strategic decisions can be evaluated. The cycle model will never be better than the data provided to it, so the input parameters must be carefully considered and measured. And empirical validation will be required before we are able to assert the conditions under which the tool provides useful insights. Nevertheless, it has the potential to aid in understanding financial data in a way not formerly available.

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