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TEACHING PRODUCTION LINE BALANCING WITH AN INTERACTIVE, SIMULATION-BASED TRAINING SYSTEM

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ABSTRACT

From 1980 to 1992 textile and apparel imports to the U.S. increased more than 250%. Foreign manufacturers have labor rates that are fractions of the U.S. standards and government statistics showed a trade deficit of almost $31 billion for 1992. As a result, approximately 420,000 American jobs have been lost representing about 20% of the labor force in the fiber/textile/apparel chain. Industry leaders and small businessmen alike recognize that this industry is in trouble and agree that the remaining U.S. advantage is proximity to the consumer. In order to capitalize on this advantage, it is imperative for the industry to attack the excessive time in inventory (83%) in the 66 week pipeline from fiber to retail.

In the apparel "cut and sew" sector of the chain, old batch manufacturing processes characterized by high work-in-process (WIP) and piece rate pay, ("Progressive Bundle Systems"), are being replaced with low inventory cellular manufacturing and "Team Sewing" group incentives. To be successful in this dramatic cultural change, a manufacturer must invest and commit to tremendous educational efforts: fostering trust and team-building, training cross-functional sewing machine operators, and most critically, developing line balancing skill in production supervisors and operators who perhaps have never had to consider such decisions before.

1 OPERATOR MOVEMENT RULES

The basic line balancing strategy for a team is to effectively move operators from task to task to manage the bottlenecks, and to smooth the work flow. The $[TC]^2$ Line Balancing Decision Trainer is an interactive, simulation based software tool designed to improve line balancing skills by leading students/users through a series of lessons and practice sessions. The user will run the trainer like a video game. An animation will play out the action of the production line, and the user will interact with the program to make operator movement decisions. When the user makes a decision the simulation will play out the consequences of the input. In this way, the students can improve their skills off-line, in a non-threatening environment, where mistakes do not incur the costs of production losses or unfilled orders.

For operators and supervisors to make effective movement decisions, there must be defined production goals and WIP limits both between operations and for the entire line. First a policy must be established that tells an operator when a decision can be made. There are two general categories of decision points, time based and situational. Once an operator gets to a decision point, there must be rules or methods that define how to select between a set of alternatives -- these procedures will be defined as "movement rules". Since movement rules can range from simple to overly complex, the Line Balancing Decision Trainer (LBDT) will allow users to devise their own combination of rules. There is a default set of rules that can be selected or new rules can be constructed with simple pull-down menus and lists.

2 STRUCTURE OF THE TRAINER

The LBDT is actually three major programs encapsulated in one menu-system interface. The menu-system itself is used to manage a database of students and control the path each user takes through the program. When a lesson is selected, the menu-system calls one of the other major components, the SIMAN/CINEMA V simulation and animation or the System Design Interface. The LBDT has 3 distinct types of users. The first is a *basic student* who has an ID number and can access the lessons and his/her personal score records. A *system designer* has additional access to define a production line and the *training administrator* is further responsible for adding and deleting students from the program and reviewing all student scores.

2.1 The System Design Interface

The System Design Interface (SDI) is a Microsoft Windows application with pull-down menus, pop up windows, presentation graphics, and on-line help designed to enable a non-technical user to quickly and easily define an apparel production system. A system designer can then define his/her own production lines so that the training is specific to the products, machines and operators of his/her plant. The SDI is functionality divided into three major categories: 1) Data Entry, 2) Data Consistency Check, and 3) Static Analysis. The Data Entry portion accepts input for the major components of a system such as Stations, Operators, Styles, Orders, etc.. After making a selection from the Main Menu, the user is presented with a screen showing a scrollable, spreadsheet style list of all the objects in that data category previously defined. From this screen, the user may copy, insert, or delete entries. More sophisticated users may edit entries directly in the list by using a special "hot-key" sequence or standard editing and adding is performed via a form type dialog box which validates inputs and provides help on the meaning and use of data fields.

The Data Consistency Check assures that the user has defined a system that is feasible to run when simulated. For example, at least one operator must be trained on each station to be able to completely process all orders. Although these items may not cause simulation "errors" they are details that indicate inconsistencies the user could have overlooked. The output from this section displays a printable list of the checks performed and whether the system defined passed or failed. The Static Analysis portion of the program calculates machine capacity utilization for each station, the number of required operators, and the cross-training necessary to cover all tasks. The user may edit the number of available machines at each station and recalculate until an acceptable design is achieved.

2.2 The Animated Simulation Model

When the user executes a lesson, the CINEMA V animation displays the scenario with icons of operators, machines and garments. Data tables display system background information such as operator training records and WIP limits. Dynamic symbols are displayed to call attention to critical parts of the system. There are signs indicating the WIP at a station is over the limit and colored lights highlighting whether an operator is in a particular state too long, such as idle, walking or waiting for parts. An "interaction window" appears when the user hits a hot key and displays a menu of choices to move operators and change system controls.

AUTHOR BIOGRAPHIES

BARBARA WERNER MAZZIOTTI is currently the Manager of Simulation Services at the Textile/Clothing Technology Corporation. For the past 3 years Mrs. Mazziotti has been challenged with bringing the technology of process simulation to the apparel and textile industries. In this position she has focused on creating data-driven, flexible simulation models and animations for non-expert users. In addition to conducting seminars on simulation and production systems, she has completed consulting projects with more that 20 retail, apparel and textile companies. Prior to $[TC]^2$, Barbara was on the consulting staff at Systems Modeling Corporation, teaching SIMAN and CINEMA, managing projects and doing analysis for a variety of industries and applications. Barbara began her career at General Motors as a Simulation Project Engineer for a group of metal stamping and automotive assembly plants. Barbara has a B.S. in Operations Research and Industrial Engineering from Cornell University and is completing an M.S. in Industrial Engineering at North Carolina State University. She is a senior member of IIE.

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