Demonstrating Warehousing Concepts Through Interactive Animations

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Abstract

In this paper, we report development of interactive computer animations to demonstrate warehousing concepts, providing a virtual environment for learning. Almost every company, regardless of its industry, holds inventory of goods in its warehouse(s) to respond to customer demand promptly, to coordinate supply and demand, to realize economies of scale in manufacturing or processing, to add value to its products and to reduce response time. Design, analysis, and improvement of warehouse operations can yield significant savings for a company. Warehousing science can be considered as an important field within the industrial engineering discipline. However, there is very little educational material (including web based media), and only a handful of books available in this field. We believe that the animations that we developed will significantly contribute to the understanding of warehousing concepts, and enable tomorrow's practitioners to grasp the fundamentals of managing warehouses.

Submission areas: Virtual Worlds, Manufacturing Systems Engineering

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Introduction

Warehousing

Warehousing is a critical function that can be found in almost every supply chain. Since warehousing typically is one of the top three cost contributors (together with transportation and inventory carrying costs), effective warehouse planning and management can significantly increase the competitiveness of a company.

Typical operations in a warehouse are receiving of inbound materials, put away to reserve and forward storage/picking areas, replenishment of the forward areas from the reserve areas, and picking, sorting, packing, and shipping orders. Warehouse planning and management begins with determining the strategic decision of which distribution strategy to employ. Then, the tactical decisions of selecting the equipment and setting the warehouse layout are made. Another tactical decision is the allocation of product groups to the areas within the warehouse. The strategy of zoning divides the warehouse into weakly linked zones where order picking takes place with dedicated labor for each zone. Another, important decision is whether to batch in the picking of incoming orders or not. Finally, operational decisions such as determining the labor schedule and the routings of order pickers are made.

The most comprehensive resources on warehousing that we have found and used in our work are the following:

- Frazelle (2002) not only provides a fascinating introduction to warehousing concepts, but also gives great insight on how to operate a warehouse efficiently. This book is intended mainly for practitioners and does not include any mathematical models.
- Bartholdi and Hackman (forthcoming) have made their lecture notes available on the Internet in the form of a book titled “Warehousing and Distribution Science”. This book, discusses the results of fundamental research studies on warehousing, besides serving as an introductory resource.
- The Progress Group[1], a logistics and supply chain consulting company, has made several white papers available at their web site. These papers are great reads for those interested in learning experts’ insights on a variety of topics in supply chain and warehouse planning.

Our work is primarily based upon the information and insights presented in the above three resources. We have singled out the concepts that we believe are crucial, and built interactive animations for each, as will be explained in detail in the next section.

E-Learning

In the last ten years, as in all disciplines, there have been attempts in the area of logistics management to train or educate students or workforce with the help of electronic learning and distance education at various levels, including corporate training

[1] http://www.theprogressgroup.com/

programs, blue collar employee capabilities enhancement, masters programs and undergraduate level courses. Although there are many alternative definitions, a description can be “E-Learning is the use of digital and internet technologies to create experiences that educate our fellow human beings” (Horton 2001).

It is possible to classify electronic learning activities from various aspects: Automation as opposed to the human tutor involvement, community management tools employed and the level of interaction, amount of games and simulations as opposed to traditional reading materials. In the age of internet and computer animation based games as the primary pastime of students, and when there are a number of various possibilities that attract them including films or activities, traditional classroom education that is not supplemented by some of the e-learning activities such as interactive multimedia animations a valuable resource is not utilized. Therefore in this study it is decided that in the teaching of logistics planning interactive animations that are characteristic in online education are to be used. This approach is expected to explain in depth the main concepts in warehousing.

Macromedia Flash

We have used the Macromedia Flash software[2] in creating our animations. The greatest advantages of this software -that played role in our selection- are the following:

- The animations created in Macromedia Flash can be viewed in practically any operating system and over the internet.
- A great percentage of internet users already have Flash Viewer installed on their computers.
- The animation files have very small sizes, due to the use of vectoral graphics.
- The Macromedia Corporation is owned by the Adobe Corporation[3] which has a strong presence on the Internet and a great influence in the software industry. The well-known Adobe Acrobat format (.pdf files) is the universal format in the academic and business world.
- The “action script” programming language within Macromedia Flash enables developers to create easy-to-use GUIs (Graphical User Interfaces) and offers many of the capabilities of a general purpose programming language (such as C++).

In designing and implementing our animation one issue that we paid attention to was to make sure that all the animations share the same characteristics with respect to interface: We used the same set of buttons, same set of font sizes and the same height-to-weight ratios in all the animations. We believe that this approach will help the users to perceive the animations as components of an integrated whole.

Related Work

Engineering Education Literature

One can find articles in engineering education literature that present impressive educational materials in various fields of engineering: Leung et al. (2001) report the development and classroom use of an animated simulation package to teach

[2] http://www.macromedia.com
[3] http://www.adobe.com

electromagnetic theory. Ong and Mannan (2002) describe a web-based courseware to teach concepts and principles in metalworking, focusing on metallurgy aspects. Their system is developed using Macromedia Flash (as in our work) together with MS Front Page web authoring system. The last example that we have chosen to mention is the system developed by Ettouney et al. (2000) for the design and simulation of thermal desalination process. This system has been used extensively in graduate, undergraduate, and training classes with great success.

Internet Resources

Bartholdi has made available on the internet several computational tools[4] to accompany Bartholdi and Hackman (forthcoming). One of these is a visualization program developed using Visual Basic that reads a MS Access database and a MS Excel spreadsheet, and gives a colored bird's eye view of a warehouse. This tool can be used in warehousing education within an engineering curriculum.

Another source available on the internet is the Interactive Warehouse[5] Java applet created by Roodbergen. The Interactive Warehouse allows users to learn about methods for determining order picking routes, which were compared earlier in an article by Roodbergen and De Koster (2001). The applet walks the user through the steps of setting a warehouse layout, creating an order, creating a route, selecting a routing method, and viewing the results.

These are the only two sources that we have been able to find on the internet.

The Animations Developed

Distribution Strategies

This animation illustrates the three basic distribution strategies of traditional distribution (with a warehouse), direct shipment, and crossdocking (Simchi-Levi et al., 2003, p133-136). We believe that this animation should be the first animation to show in an introductory warehousing presentation, since it gives an overview and a general understanding of a warehouse (and a crossdocking facility) within the general context of a supply chain. In traditional distribution the warehouse serves as a storage point, where products incoming from the suppliers are putaway to various locations in the warehouse to be stored for some time (which can be in the magnitude of years) and then picked for shipment to demand points (Figure 1a). Direct shipment takes place when the supplier sends its shipments directly to demand points, bypassing the warehouse (Figure 1b). In crossdocking, the suppliers' trucks do visit the so called "crossdock facility", but the products are not stored for more than 24 hours (Figure 1c). Crossdocking can bring significant cost savings but should be carefully planned and coordinated.

Order Picking Schemes

Next animation that we present summarizes the picking schemes in a warehouse. Freeform picking takes place when there is no zoning in the warehouse. In this scenario, two possibilities are single order picking and the batch picking (Figure 2a). In single

[4] http://www.tli.gatech.edu/whscience/supplement.html
[5] http://www.roodbergen.com/warehouse/

order picking, the order picker travels on a new route to pick each new order (Figure 1b). In batch picking, the order picker picks two or more orders on the same route.

In zone picking, each order picker is allocated to a particular zone, and is responsible of picking the orders in his/her zone. Since the items within the same order may be picked at different zones simultaneously, there is a need to combine these picks into a single whole. Two strategies to achieve this are progressive assembly and downstream sortation. In progressive assembly the first order picker picks the items in an order that reside in his/her zone, and puts the tote/box containing the incomplete order to the origin point for the second zone (Figure 2c). The next order picker seizes what the preceding order picker has accumulated and continues picking the items in the order that reside in his/her region.

In downstream sortation strategy, the order picker in each zone leaves the incomplete order that he picked into a conveyor, and the conveyor carries the totes/boxes to a sortation point (Figure 2d).

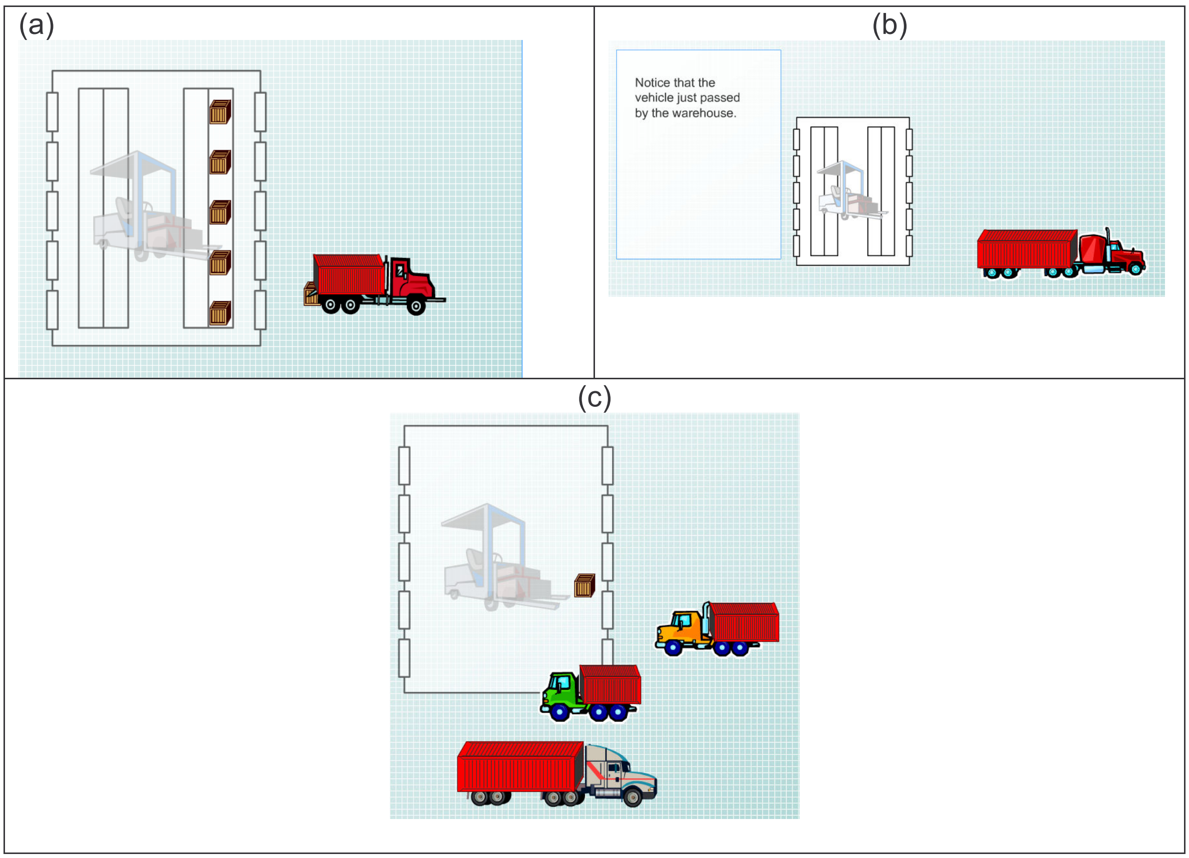

Figure 1. Distribution Strategies

(a)

(b)

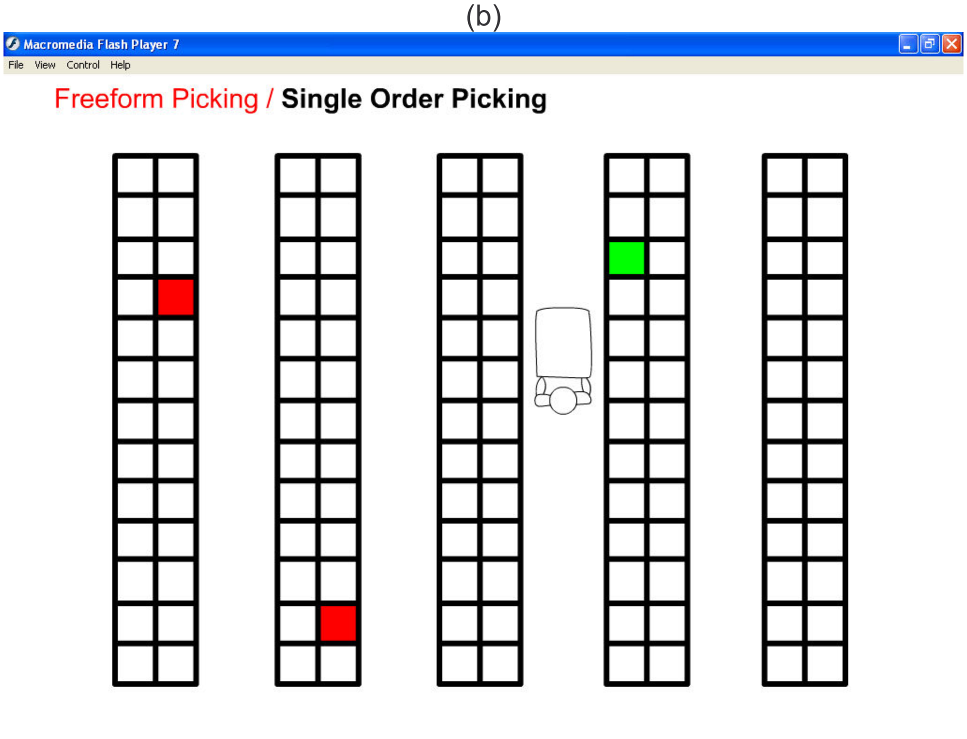

Figure 2. Picking Schemes in a Warehouse

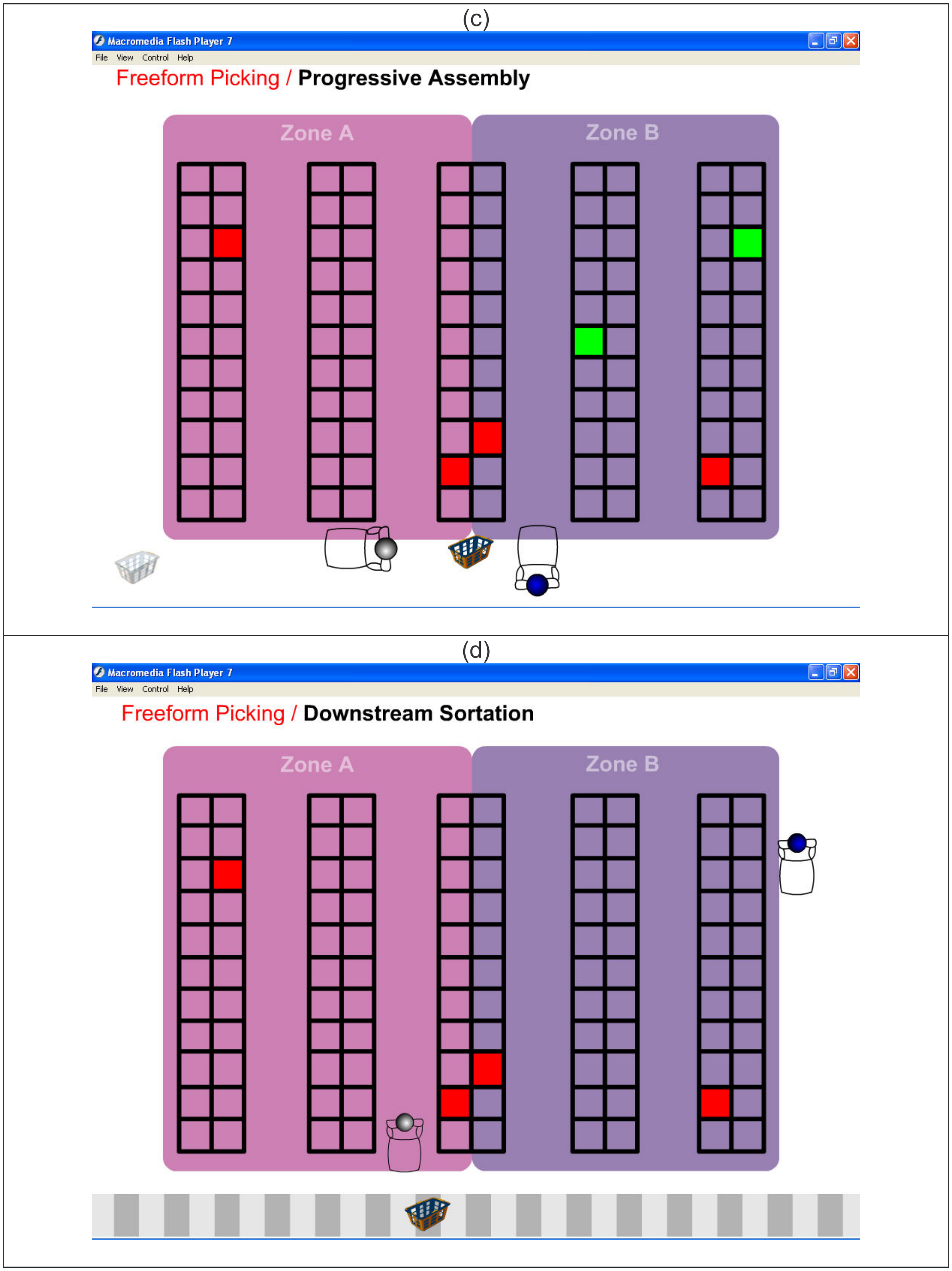

Figure 2 (continued). Picking Schemes in a Warehouse

Pick-to-light System

Order picking in most warehouses involves minimal technology. A typical order picking tour starts with receipt of a picking list, which displays the item number (also referred to as SKU number, standing for Stock Keeping Unit), the item location and the number of units to pick. The order picker sorts the items to be picked in his mind, and visits each item's location to make the picks (Figure 3a). Tasks that consume time during this classical mode of order picking are traveling, searching, extracting and documenting.

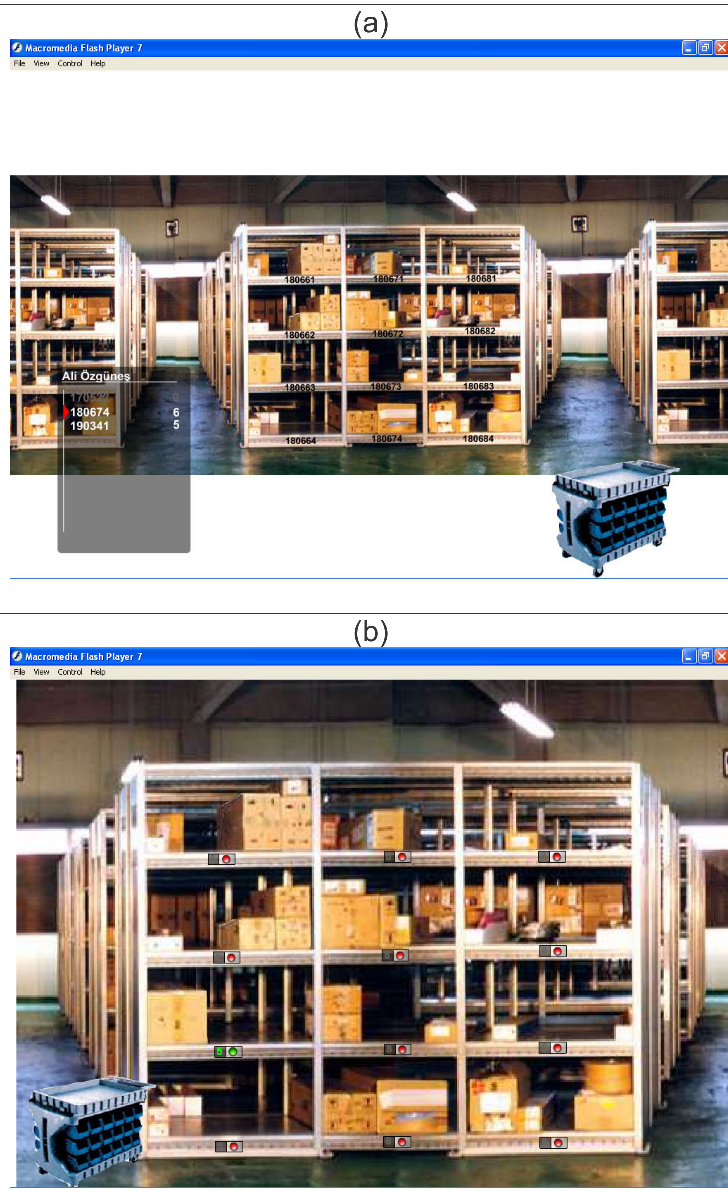

Figure 3. Pick-to-light System

One problem encountered in most order picking operations is the erroneous picking of items. A pick-to-light system is a solution that technology offers to reduce the times for the mentioned tasks and to reduce order picking errors (Figure 3b). In a pick-to-light system, an indicator light and an electronic numeric display inform the order picker on where to pick from and in what quantity. The order picker is relieved from the burden of searching the item locations and -to a degree- relieved from other tasks. Picking errors are also observed to decrease when pick-to-light systems are implemented. Thus the pick-to-light system is a viable option that can reduce costs and increase order picking accuracy in a warehouse.

Bucket Brigade

Let us consider a forward pick area, where a number of order pickers (for example three of them) perform picking at varying speeds. A fundamental question is the following: How should the order pickers be placed on this picking line? Two alternatives that come to mind immediately are sorting the pickers from the slowest to fastest and sorting them from the fastest to the slowest. Theoretical and empirical research by Bartholdi and Eisenstein (2006) show that the former is indeed the optimal alternative. The bucket brigade animation that we have developed illustrates how this takes place through animation. The user can observe in the fast-normal-slow picker sequence (the simulation below) how the slow picker blocks the progress of the fast picker. In the slow-normal-fast picker sequence (operating mode) the fast picker clears out any material downstream and takes over the work upstream from the slow picker.

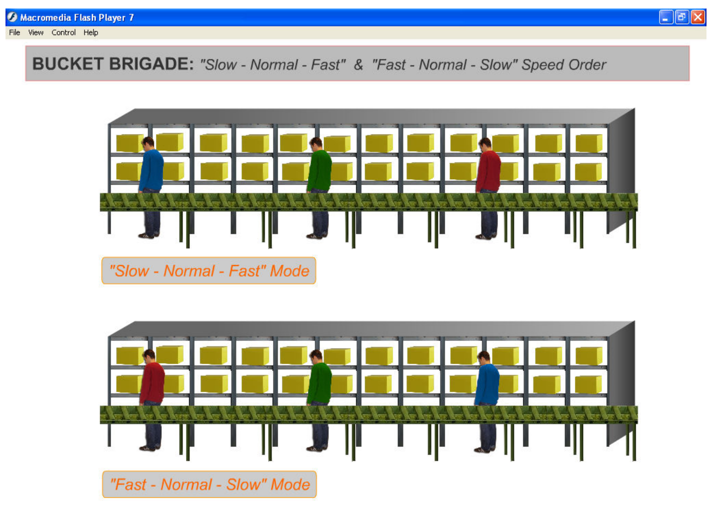

Figure 4. Bucket Brigade

Carousel

Carousels are automated equipments that store small items in the shelves of their carriers and bring the items to order pickers (Figure 5). In practice two or three carousels are assigned to a single order picker. This way the order picker can pick from other carousel(s) instead of waiting while one of the carousels is rotating. In our animation the order picker is given a pick list, and is responsible of picking from three carousels. The picker is able to initiate the rotation of each of the carousels, and picks the items that are brought in front of him. When he is finished with picking all the items in his list, he leaves his tote to a conveyor that will take it to the sorting area.

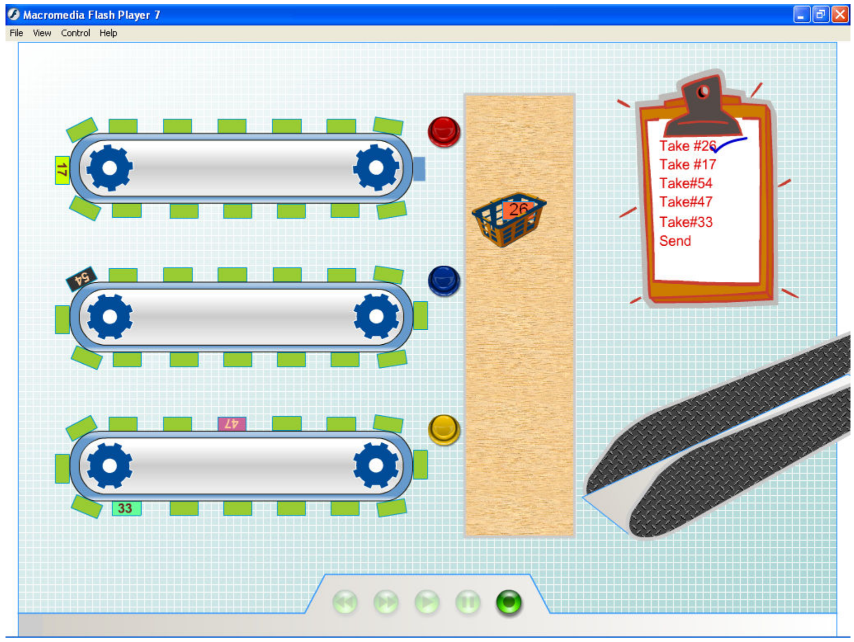

Figure 5. Carousel

Order Picker Truck

An order picker truck enables the order picker to pick items from high level storage locations (Figure 6). The normal operational mode in which the order picker truck uses in visiting pick locations is the "nearest neighbor" mode, where the picker visits the next closest pick location at each step. An alternative mode of operation is the "sweep" mode, where the order picker picks all the items at a certain level before starting to pick the items in the next higher level. Our animation simulates and time wise compares these two modes of operation.

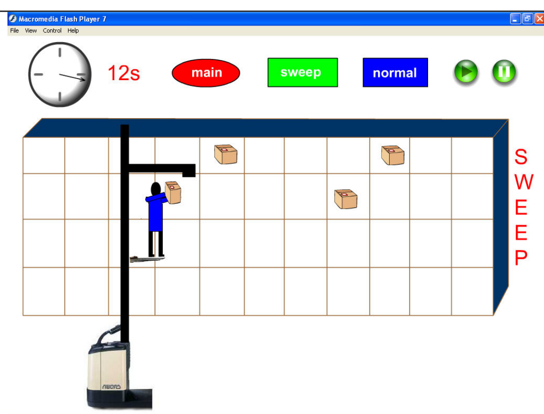

Figure 6. Order Picker Truck

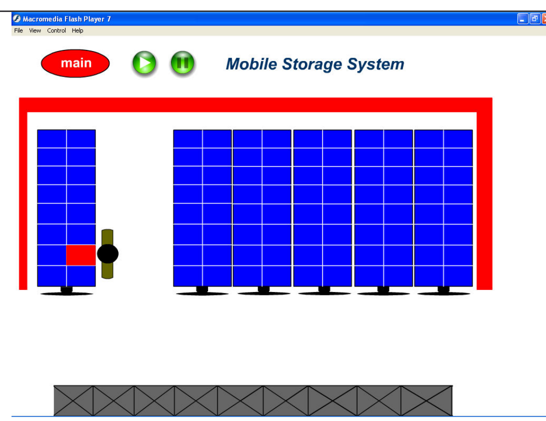

Figure 7. Mobile Storage System

Mobile Storage System

A mobile storage system is used to store items that are requested very infrequently (Figure 7). The main advantage of a mobile storage system is its space efficiency: There is only a single aisle empty at any time. When the picker is to pick an item from the system, the system creates an aisle dynamically to be able to make the pick. This system is typically used by media companies, state institutions and hospitals to store archived documents.

Conclusions

We have presented our work towards creating and integrating web-compatible educational media into warehousing education. Our work is unique since we have not found any other similar work in the field of warehousing, except two web sites.

Possible future work in this topic involves development of other media for warehousing education, including not only web based demonstrations/animations such as Java applets and Flash animations, but also interactive 3D models of warehousing equipment, as in the work of Ou et al. (2002). There is ongoing work going on at Sabanci University for developing such educational materials.

One study that would contribute to the use of current media and further development of educational materials in the future is measuring the usefulness of the developed media. This can be done through formal surveys with users (senior and junior students at Sabanci University) and analyzing the surveys thoroughly.

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