On the Two Abstractions of Social Information and Plato's Theory of the Separation of Particulars and Universals

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***Abstract*—Computers have important roles in determining solutions to Industrial and Systems Engineering problems. Various technologies can be used for solving different types of problems in engineering and design of these systems do impact students' learning. The objective of this article is to give examples of how FlexSim can be used in a simulation course and investigate undergraduate Industrial Engineering students' project design experiences using Flexsim 7.3.2 as a part of their real-life semester based course projects. The findings presented in this paper are collected throughout three years and a pedagogical method for teaching a simulation course with the corresponding learning outcomes are explained.**

***Index Terms*— Simulation, Systems, FlexSim, Course projects**

INTRODUCTION

INDUSTRIAL engineering is a branch of engineering which deals with the optimization of complex processes, systems or organizations. Industrial engineers work to eliminate waste of time, money, materials, man-hours, machine time, energy and other resources that do not generate value. Simulation software such as FlexSim [1], AnyLogic [2], and Simio [3] are often used for determining Industrial and Systems Engineering solutions for various service and production systems. Simulation solutions are also often obtained for various engineering problems [3] - [7]. Desirable features of a simulation software include

1. User-friendliness;
2. Interactive use capability;
3. Allowing complete runs;
4. Needs to be easily understood by users;
5. Having macro capability;
6. Allowing modules to build from sub-modules;
7. Allowing users to write and incorporate their own routines;
8. Containing built-in commands for building blocks;
9. Include material-flow capability;
10. Capability of producing standard output statistics such as cycle times, utilization, and wait times;
11. Analysis of input and output data in a variety of ways;
12. Graphical display of the product flow through the system with animation;
13. Debugging capability interactively.

The simulation software solutions have advantages and disadvantages. The advantages of using a simulation software solution include

1. Independent from the real system therefore it doesn't impact the daily work flow;
2. Helping to understand the details of the simulated real system;
3. Compression of years of real system experience into seconds or minutes;
4. Generates a set of numbers for different possible scenarios that can be used for industrial engineering solutions;
5. Availability of many free simulation software for educational purposes;
6. Capability to use simulation as a game for training experience;
7. Providing a replication of the system more realistically compared to mathematical modeling;
8. Transient period analysis is possible while such an analysis may not be possible using mathematical techniques;
9. What-if analysis for desired aspects of the system;
10. Ability to use Cloud for interactive applications.

The disadvantages include

1. Good answers are not guaranteed;
2. Reliability may not be possible;
3. Structuring a simulation model can take a lot of time;
4. Simulation results can be less accurate compared to mathematical models' analysis due to the random number generation nature;
5. Time and memory that may be needed to run complex models;
6. Unstandardized approach to solve problems.

The main contribution of this work is to provide educational information on Industrial Engineering students' hands-on real-life course project experiences by using FlexSim simulation software. There are many FlexSim Simulation applications in health care, manufacturing, and service systems' design [8]. In this work, several examples to FlexSim applications will be given and explained. In addition, junior and senior level Industrial Engineering students' experiences with the use of FlexSim in real-life manufacturing environments will be explained as a part of a Simulation course's semester project throughout the three years that the course was offered.

FlexSim Applications in Health Care

Simulation software solutions in health care can be particularly used for designing and experimenting surgical uncertainties. Figure 1 given below displays a surgical model in which two groups of patients arrive to a hospital 10 minutes before and after expected times. The administrating operators assist the patients to the surgery room. There are lab and bloodwork areas that take place in the simulated environment as a part of the surgical operations. After patients are treated, they leave the hospital. There are statistical distribution assumption for simulating the environment. Noting that FlexSim accepts Excel data in a specific format, the actual surgical environment can be replicated by using the real-time data. Basic C++ coding can be used for FlexSim implementations.

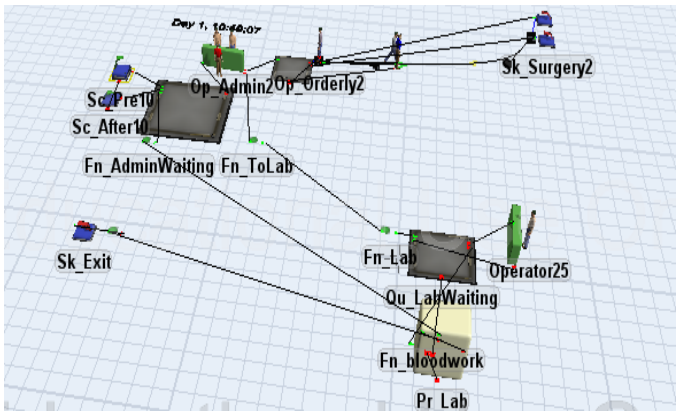

Fig. 1. An application of FlexSim software in Health Care

FlexSim Applications in Production Systems

FlexSim software solutions for controlling production systems are often seen as applications of FlexSim. For instance, the solution in Figure 2 is designed for a system with 3 parallel production lines with different items produced. In each line, the raw items in the source are pressed at the first available processor down the production line. The pressed items are then engraved down the line. The engraved items are passed onto the quality control processor via a conveyor. Quality approved items are then send to the sink of finished items. If a defect or scrap is determined then it is taken out of the production line and sent to the sink called "Loss". A system controller is given the ability to control the pressing and engraving parts of the production. The finished items can be sent to any one of the seven "FinishedItem" sinks in the production line.

Another application of FlexSim is determining average and total grain shipment amounts in tons. The simulation solution in Figure 3 displays statistical efficiency of the grain distribution that initiated with the main grain storage center feeding the four sub-storage units. Trucks are then loaded with grain and routed to distribute the grains to various different destinations. The statistics for shipped grain is displayed on the 3D simulation environment with yellow and white squares on left top corner of Figure 3 below.

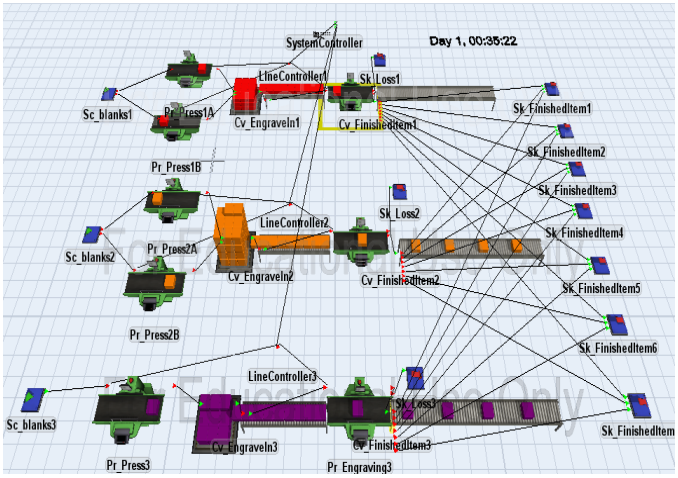

Fig. 2. An application of FlexSim software in a controlled production system

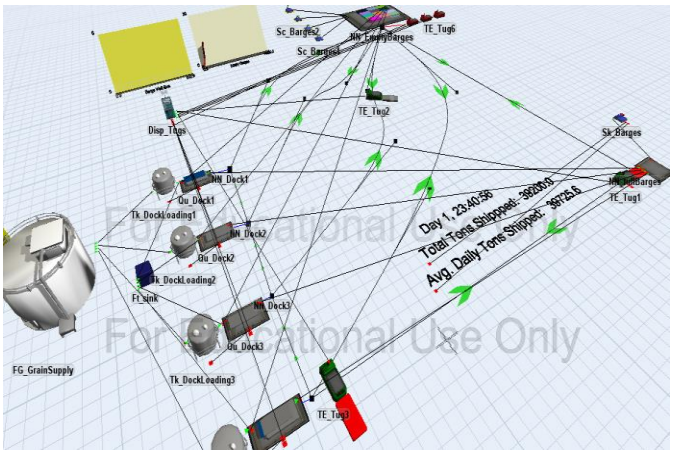

Fig. 3. An application of FlexSim software in a grain production environment

FlexSim Applications in Purchasing Systems

An application area of FlexSim is service systems such as grocery stores, online sales etc. A purpose of the simulation solution is to find the right service level to dynamically changing (i.e. stochastic) customer arrivals by considering customers' decision making. The following graph displays customer arrivals to a store and their decision making on purchasing a certain product. The arriving customers start shopping process in Figure 4 after they are generated by the source. The customers are then queued for decision making. If a customer decides to purchase the specific item then the customer joins the checkout queue right away to proceed to the checkout process next. If a customer joins the "CustomDecision" queue then the customer proceeds to the no-purchase queue if he/she decides to not purchase the items and checkout queue otherwise. The custom decision requires one more step before checking out the item. The statistical data is collected for the sales and shopping experience of customers within the store.

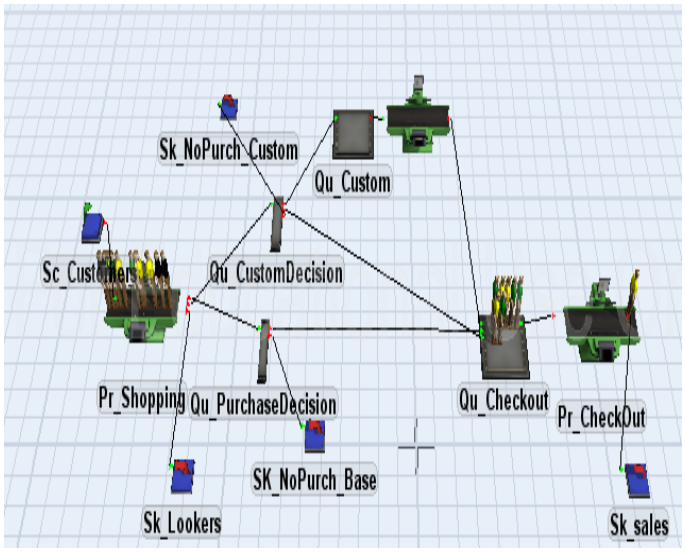

Fig. 4. An application of FlexSim software in a purchasing system

FlexSim & Inventory Management Systems

An application of FlexSim is to design and experiment alternatives for inventory management systems considering what-if scenarios. In the case when there is a need to change an existing inventory management system, several alternative inventory management systems can be tested to determine the best option. Assume that a firm uses a manual shelf-management system (i.e. a management system in which the items are collected manually from the shelves by workers) and a change in this methodology is needed due to the growth in the number of orders. The following figure displays an automated shelf-inventory management system that can replace the manual system to increase the efficiency of the existing operations. A set of different scenarios can be tested with the changes in the processors' stochastic model parameters for determining the most efficient operational settings.

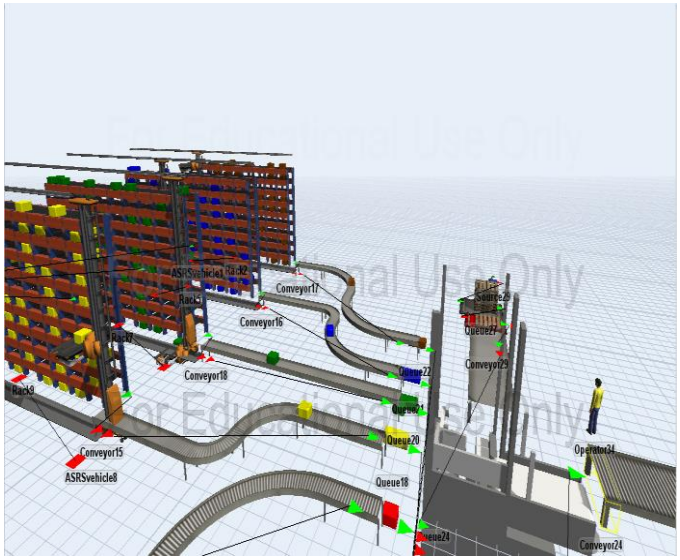

Fig. 5. An application of FlexSim software in an inventory management system

FlexSim & Gaming

The Zombie game [1] is a free simulation game developed by FlexSim used for increasing middle and high school students' interest to simulation. It is a practical way to initiate a sense for K16 students to understand how simulation works from managers' perspectives. The game has a setting in which zombies (customers) need energy cubes (goods to purchase) and you need to manage the production area to maximize revenue and minimize expenditures. The penalty cost for being unable to match zombie demands appear as the zombies' attempts to destroy the machines in the environment. The expenditures and revenue are calculated automatically and displayed on the side of the screen. The player manages the work environment by purchasing machines and employing workers to balance the production. Producing too many energy cubes result in holding costs while underproduction results in destroyed machines. Determining the bottlenecks during the production is the key point for success where the players are expected to observe during the implementation of the game.

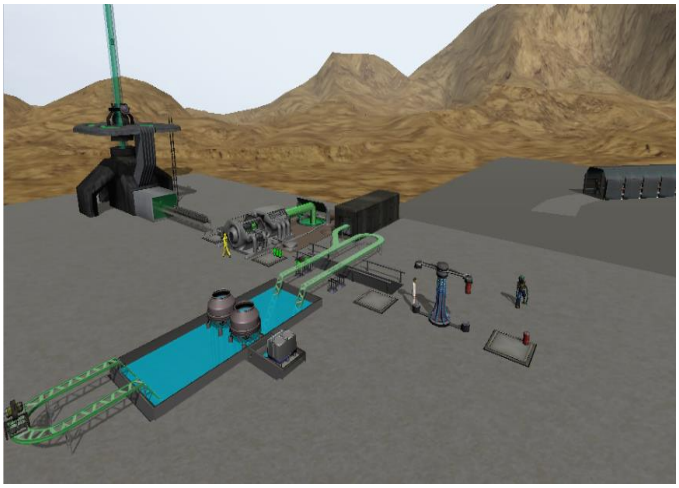

Fig. 6. An application of FlexSim in gaming

Simulation Course Learning Objectives

The following learning objectives outline the course concepts and explain how the course concepts are structured around the 3D software applications:

1) Understand the basic decision models;
2) Understand how to use FlexSim models for system simulation and analysis;
3) Learn the principles of static simulation and its applications in engineering by using FlexSim 3D software;
4) Learn the principles of dynamic simulation and its applications in engineering by using FlexSim software;
5) Implement system modeling concepts for discrete-event simulation;
6) Understand how to implement system modeling in manufacturing;
7) Learn how to solve problems in transportation service systems.

These objectives serve well for ABET's A-K outcomes for program accreditation purposes. Examples of students' hands-on real-life experiences by using FlexSim software are given below. Both the educators and students can benefit by reading these examples and learn from these project experiences.

FlexSim Simulation - Semester Project 1

Applications of course concepts are learned best in practice. Students enrolled to the junior-level simulation course during the spring school semester of 2015 worked with a manufacturer in CT to simulate a production line. Students who registered to the course worked with the facility manager as a single group and requested data to simulate the existing environment. Each student then worked on their own simulation solution with their own ideas that can be implemented for improvement. Improvement ideas included changing the locations of the machines and levels of production with the changes in the statistical distributions. The following figure displays the graph of one of the student's improvement ideas in the production line.

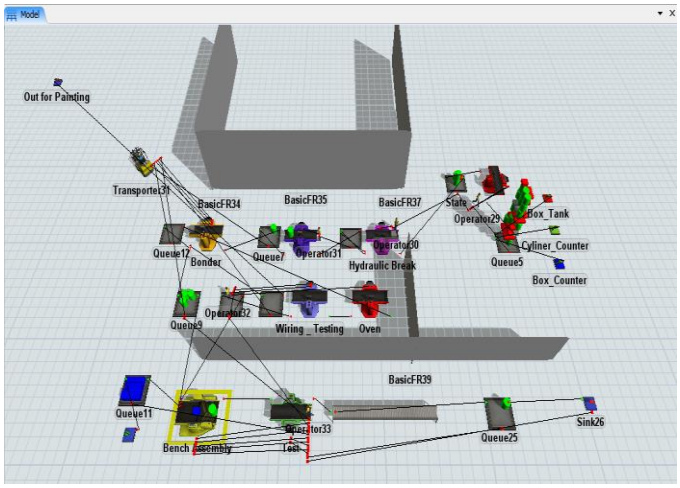

Fig. 7. A course project completed in 2015– Improving a production line in a manufacturing setting

FlexSim Simulation - Semester Project 2

The improvement of a manufacturer's production and transportation system was the objective of the junior-level simulation course during spring of 2016. Manufacturer's production and transportation processes are both simulated by using FlexSim. Students work with the plant manager to collect data and design the production specifics. The production of the manufacturer starts at Facility 1 and the finished items are then send to Facility 2 in a different state. The items processed in Facility 2 are sent back to Facility 1 for further processing to attain the finalized item. Students initially worked on the project as a single group and collected data. Students worked in groups of 2 and 3 to have their own improvement ideas implemented in the production line after the initial data collection phase. The bottom right corner of Figure 8 represents Facility 2 while the rest of the figure displays the processors and queues of Facility 1.

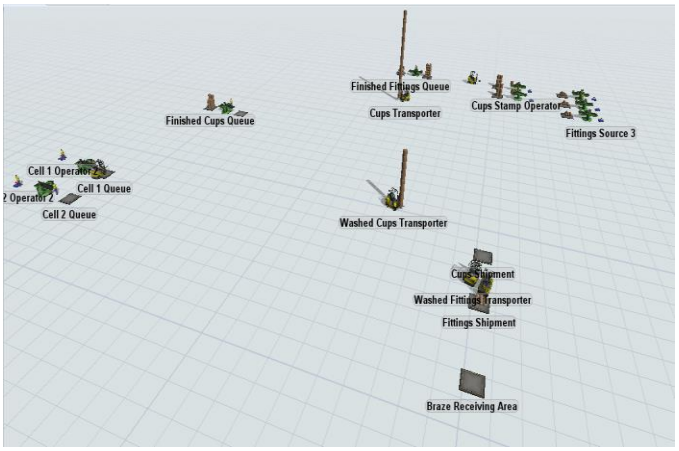

Fig. 8. A course project completed in 2016– Improving transportation in a manufacturing setting

Student Work – Assignment Projects

Simulation course assignments included various FlexSim questions and training modules. Students were asked to complete the FlexSim training modules before they started to work on assignment questions. One of these questions was to simulate an airport check-in system. Three parallel lines are expected to be placed in the simulation environment for airport check-ins assuming a line for paper ticket, a line for online tickets, and another line for business class. These three channels all had the same physical components: sources for travelers' arrival to the airport, conveyors for travelers' waiting lines, processors for checking in travelers, and sinks for travelers to leave the check-in area. The physical components for each check-in line had different statistical distribution assumptions. In Figure 8 below the three parallel channels of traveler check-ins are shown. The purpose of the exercise is to first simulate the existing check-in environment and then to find a way to improve the check-in area if there are lines that have bottlenecks. The figure below also shows errors in the System Console. Even though students do not code in this exercise, the system console still showed errors in the implementation of the program; however these errors did not impact the simulation runs. The attained errors were related to exceptions or received messages.

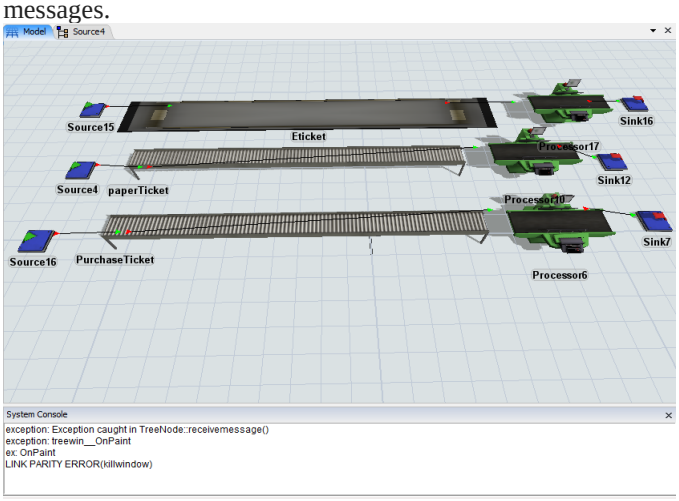

Fig. 9. An Example of a conveyor line production simulation with errors

Conclusion

Simulation is one of the best ways to view the strong impact of computers in today's education with its' 3D views and its' calculation ability. In this work, simulation examples to health care, production, purchasing, inventory management, and production systems as well as gaming are explained for a particular simulation software named FlexSim. Simulation software solutions are commonly used for determining levels of operational excellence and cost reduction. Considering the desired features of a simulation software explained in the introduction, FlexSim is user-friendly, has the interactive usage capability, allows complete runs, easy to be understood by the users, has the macro capability, modules can be built from the sub-modules, allows users to write and incorporate their own routines if needed by using C# or C++ coding, contains built-in commands for building blocks, includes material-flow capability, capable of producing standard output statistics such as cycle times, utilization, and wait times by using Excel, can analyze input and output data in a variety of ways, has the 3D graphical display ability for the product flow through the system with animation, and allows debugging interactively if there is program coding required.

Simulation software solutions' advantages and disadvantages are explained with course project and assignment examples that are collected throughout three years. One of the main issues that arose during the semester projects was the accuracy of the actual data received from the manufacturers that students used for simulating the environment. Even though the data used for simulation solutions may not be reliable in certain applications, the simulation runs can still result in a 3D output in which operations are visible and improvement opportunities are available through the simulation implementation. The comparison of the initial and final simulation's assumptions and outcomes help to analyze the changes mathematically. Real-life simulation projects related to operations management completed by the students showed how much they enjoyed and benefited from the integration of mathematical models and visual representations of real-life objects in the 3D software environment. Many students enjoyed making changes in the software environments that reflect the actual real-life operations and observed how the operations react to these changes.

Appendix

Simulation Course Project Description

The main goal of this simulation project is to implement the Simulation course concepts in real life manufacturing setting(s) by using the simulation techniques covered throughout the course with FlexSim software simulation.

All of you as a group will need to interview the project owner (TBD) at the site of the manufacturer who will recommend you a certain production line for improvement.

Due to the completion of this project, you are expected to have

1. A detailed written description of the chosen production line within the manufacturer
2. A FlexSim program developed as a result of all groups' collaborative effort for the current layout
3. A FlexSim program developed by each group for the improvement of the existing production line
4. An Excel spreadsheet developed by each group that displays the statistical results before and after the improvement efforts.

The following are expected (but not limited) to be implemented in your project.

- State the problem after determining the following:
  - Machines used for the production
  - Locations and distances between the machines within the facility clearly defined
  - Number of employees, their functions number of hours they work, breaks taken etc.
  - Inventory assumptions (Frequency of items received, item availability etc.)
  - Number of items produced and the statistical distribution assumptions or data used for implementation of the FlexSim program
  - Machine downtimes
  - Use appropriate assumptions that align well with the current employee work hours and machine operations
- Change machine locations for testing the impact of this change on the production
- Identify any improvement opportunities other than changing the locations of the machines
- Implement statistical results using FlexSim before and after the changes in the production line
- Recommend changes to the project owner by using the conclusions drawn from your simulation analysis

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