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INTEGRATING THE CAD MODEL WITH DYNAMIC SIMULATION: SIMULATION DATA EXCHANGE

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ABSTRACT

Engineering Animation, Inc. (EAI) has developed a number of intelligent CAD objects for facilities design. These objects allow the facility designer to design and modify the facility layout with minimal effort and tedious drafting duplication.

Facility Layouts that are designed by the facilities group often have to be dynamically simulated to prove the concept and to determine if the required throughput (jobs per hour) can be achieved. Traditionally this requires the simulation engineer to duplicate the CAD drawing in the simulation environment before being able to model it. This is also not a one-time duplication of work as the facility layout can go through numerous revisions before the final equipment configuration is determined.

FactoryCAD® layout objects are embedded with simulation relevant data such as Time to Fail, Time to Repair, Cycle times, Scrap rates, Speeds, et cetera. An intelligent extraction routine then exports object details such as type of object (machine, conveyor, buffer, etc.), object location, and other physical parameters, along with all simulation relevant data that had been previously embedded into the objects from the layout into a standardized ASCII text file. This will eliminate the need to recreate physical and even some run control information in the dynamic simulation package. It is proposed that the most effective data transfer would be to create a common data format (Simulation Data Exchange - SDX) that can serve as an input to the automatic generation of discrete event simulation models.

The simulation model generates animation data that is subsequently available for dynamic viewing and analysis in the FactoryVIEW™ environment.

1 OVERVIEW

Engineering Animation, Inc. (EAI) has developed a number of intelligent CAD objects for facilities design. These objects allow the facility designer to design and modify the facility layout with minimal effort and tedious drafting duplication.

Facility Layouts that are designed by the facilities group often have to be dynamically simulated to prove the concept and to determine if the required throughput (jobs per hour) can be achieved. Traditionally this requires the simulation engineer to duplicate the CAD drawing in the simulation environment before being able to model it. This is also not a one-time duplication of work as the facility layout can go through numerous revisions before the final equipment configuration is determined.

In order to reduce the duplication of work it is proposed here that the information embedded in the FactoryCAD® (AutoCAD®) objects are transferred to the simulation package of choice. This will eliminate the need to recreate physical and even some run control information in the dynamic simulation package. It is proposed that the most effective data transfer would be to create a common data format (Simulation Data Exchange - SDX) that can serve as an input to the automatic generation of discrete event simulation models in tools such as AutoMOD®, Witness®, Taylor ED®, Arena®, Promodel®, et cetera.

The basic purpose of this project is to develop a seamless and automated method of generating simulation models and 3-D model animations directly from CAD drawings. FactoryCAD® layout objects are embedded with simulation relevant data such as Time to Fail, Time to Repair, Cycle times, Scrap rates, Speeds, et cetera. An intelligent extraction routine then exports object details such as type of object (machine, conveyor, buffer, etc.), object location, and other physical parameters, along with all simulation relevant data that had been previously embedded into the objects from the layout into a standardized ASCII text file known as a SDX file. Also, a dynamic link with any ODBC compliant database allows the SDX file to have part information such as part numbers, routing, individual part cycle times, scrap rates, and set up times. Thus, the SDX file now has a complete set of organized data from both, the CAD model as well as any database that contains material routing, and other

manufacturing related data. The simulation model is then generated automatically from this ASCII flat data file via a translator developed by the discrete event simulation tool developer. The simulation model generates animation data that is subsequently available for dynamic viewing and analysis in the FactoryVIEW™ environment.

This document is designed to provide the reader with information pertaining to the requirement of features, in the sense of purpose, events, and response. This document is limited to detailing out the transfer process between FactoryCAD® and discrete event simulation tools.

The project consists of integrating several mature applications by developing new methods of automating the transfer of data. This document outlines the integration solution between FactoryCAD®, Discrete Event Simulation Tools, and FactoryVIEW™.

The general process consists of the following capabilities (some of which may not be used in any given scenario):

- Create a 3-D model of the layout using FactoryCAD®.
- Import graphic objects directly into layout drawings from 3rd party applications (i.e. tooling, robots, part data, etc).
- Embed simulation relevant data into the objects of the FactoryCAD® 3-D model of the factory.
- Embed simulation relevant data into the imported 3-D graphic blocks.
- Generate a formatted ASCII flat file (SDX file) describing the manufacturing data and layout.
- Translate the SDX file into a simple simulation model.
- Import other exchange data and other model input data (separately maintained – outside the scope of this project), into the simulation model just created, run the simulation model using the simulation software.
- Generate animation script and data files.
- Import additional static graphics objects into FactoryVIEW™ from 3rd party applications along with aforementioned animation script/data files for animation generation within FactoryVIEW™.

2 FACTORYSIM™ ARCHITECTURE

The chart shown below describes the entire architecture of the FactorySIM™ interface. The individual processes are described in greater detail in the following sections.

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2.1 Graphics Import/Export

Facility layout drawings are developed using EAI's FactoryCAD® (run from within AutoCAD®) application

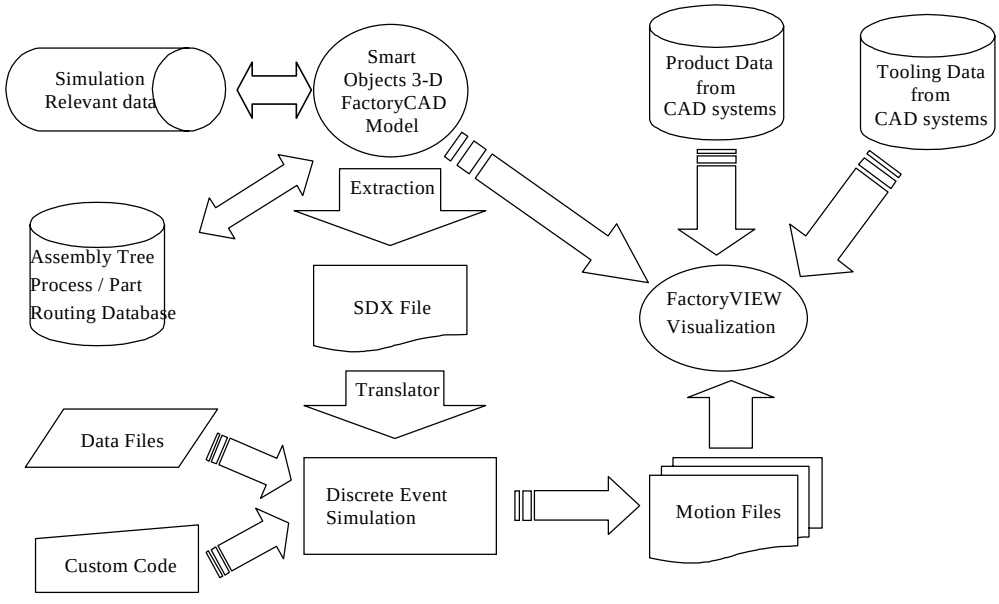

Figure 1: Simulation Data Exchange Architecture

with intelligent 3-D objects representing various manufacturing / assembly / material handling entities. This can be either a detailed drawing or, a cartoon. Apart from being intelligent (with regards to geometry), these objects have individual identities such as machine, conveyor, overhead power & free, buffer, vehicle, et cetera. Manufacturing data, such as downtime details, speeds, cycle times, scrap rates, and other object-specific information is saved as attributes of the objects. The FactoryCAD® model may be viewed as a 2-D drawing or a 3-D model (both may be displayed simultaneously) to facilitate further refinement or modification.

EAI has added functionality to FactoryCAD® to generate the Simulation Data Exchange (filename.sdx; see next section for details) file. The SDX file is a compilation of physical data, manufacturing and production data, and simulation data (run length, etc.). The content of the SDX file is generated from user input of various manufacturing data and simulation parameters through custom menus and other data contained (i.e. position) in the objects in the drawing. The SDX file is ASCII text and is formatted according strict conventions spelled out in the next section.

2.2 Simulation Data Exchange (SDX) File Description

An ASCII text file is generated from FactoryCAD® (named by the user with extension ".sdx"). This file is used as input information (along with other generic input data externally maintained), to generate and run a simulation model of either the entire layout represented on the drawing or a specific windowed area. The file contains header information specifying drawing source data, simulation model units, run control and shift information.

Following the header section of the SDX file, any number of objects is defined. Some of the types of objects are PART, CONVEYOR, OVERHEAD POWER & FREE, VEHICLE, MACHINE, BUFFER, PATH NETWORK, P&F_NETWORK. Apart from objects that have an actual geometric shape, there are other objects like SHIFT, RUNTIME, and STATISTICS. Depending on the type of object, a number of related "details" describe all of the attributes of the object necessary for the simulation model. The objects are listed one after the other, as the extraction routine traverses through the layout. Within each object, that is, between every [OBJECT BEGIN] and [OBJECT END] object parameters and other stored values (TTF, TTR, Setups, Cycle Times, Cost Data, etc.) are listed against descriptive field names. This makes it very easy for the translation tool to read the SDX file and build a model.

The current file format can be referred to, in the appendices. This spreadsheet contains preliminary and other additional SDX file requirements.

2.3 Feature Requirement

Factory layout drawings will be developed / created / modified in FactoryCAD®. These drawings will have intelligent 3-D objects that will contain most simulation relevant information required to create a basic simulation run.

The following are the examples of different object types that will be stored within the drawing that will in turn contain all simulation relevant information:

I. LOAD
II. SHIFT
III. CONVEYORS–FLOOR and OVERHEAD
IV. REG_MONORAIL SYSTEMS
V. VERTICAL LIFT SYSTEMS
VI. TRANSPORTERS
VII. AISLE NETWORKS
VIII. CARRIER
IX. BUFFER
X. MACHINE
XI. STATISTICS
XII. RUNTIME
XIII. ROUTE
XIV. PROCESS
XV. CONNECTION
XVI. WORKCENTER

These objects will contain information as given in the appendix.

2.4 Data Embedding

2.4.1 Purpose

This feature allows the objects in the drawing to be embedded with simulation relevant information.

2.4.2 Events

- The user chooses to create an object from the object toolbar.
- The program retrieves information from a central DEFAULT file which houses default information of all objects that need simulation information embedded in them.
- The user traverses through the different menus and modifies information as required.
- Finally, the user creates an object defining shift and run-time information and populates the different fields. This is done one time, and the user does not have to populate this information each time a simulation run is desired. However, this information can be edited if and when required.

- The user will create / modify / append the routing file in an external database, which shall contain all the part numbers that need to be considered.

2.4.3 Response

- The system will maintain a dictionary of entries so that a name of an object is not duplicated anywhere in the drawing.
- The system will allow objects to be queried to edit information previously entered.
- The system will have basic error handling to flag incorrect data.

2.5 Extraction Routine

2.51 Purpose

This feature allows the objects in the drawing to be queried and data retrieved to an ASCII format text file (with the extension SDX).

2.5.2 Events

- The user clicks an icon on the AutoCAD® / FactoryCAD® screen.
- The user enters shift and run-time information if not already provided.
- The users can either window an area or select the entire drawing.
- The software traverses through the drawing, recognizing, and retrieving simulation information from all the objects.
- From a provisional drop down box, the user selects all the parts that have to be considered in the simulation run.
- The user enters a file name to store the SDX file.

2.5.3 Response

An SDX file is generated that contains all the objects, their relevant information, assembly tree structure, and part routing in ASCII format.

2.6 Run

2.6.1 Purpose

This feature allows the creation of a discrete event simulation run automatically / seamlessly / separately from the SDX file generated.

2.6.2 Events

Immediately upon the completion of the SDX file creation, the user is prompted that allows a simulation run to start immediately.

2.6.3 Response

The system will invoke a simulation program / translator from a drop down box (list, if a number of translators are available to that user) that would automatically traverse through the SDX file just created and create the model.
The translator can also be started separately, to translate a different SDX file.

3 SIMULATION TOOL INTEGRATION REQUIREMENTS

3.1 Purpose

This feature will list out the requirements for the most translators. The primary objective of the translator is to create a simple model.

3.2 Events

- The user can invoke a translator from within FactoryCAD®.
- The user can start the translator from outside and open a SDX file previously created.
- Alternatively, the translator may be part of the simulation software.
- The translator will also scale to the coordinates provided by the SDX file.
- This system will place all relevant factory objects in the same manner as defined on the layout.
- The system will absorb the data provided in the SDX file (MTBF, MTTR, SPEED, SETUP, et cetera) within each element created.

3.3 Response

- The system will output out motion descriptions / transformation matrices that will be read by FactoryVIEW™.
- The system will notify the user of any anomaly in the structure of the model.
- The system will output out statistics of all objects in the model that will be stored in the STATISTICS object of the FactoryCAD® model.
- To accommodate missing or other data that cannot be contained in a FactoryCAD® file, the translator will fill in those fields with default parameters.

4 ANIMATION IMPORT/EXPORT

EAI's FactoryVIEW™ is used for animation. This is not only capable of importing and using graphics directly from AutoCAD, but also, from other applications such as RobCad/Dynamo® (Robotic workcell kinematic simulation), Unigraphics®, CATIA®, (CAD tools) et cetera. These static graphics may be used to represent loads, facility structures, or any other static model component.

FactoryVIEW™ is used as the interactive viewer during simulation runs or in a "post-process" mode after a simulation run. It is assumed that users may not always want the enhanced graphics during run-time control, but might find it useful in certain cases.

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