

DESIGN AND DEVELOPMENT OF BASIC LEARNING MODULES FOR OPEN-SOURCE JAAMSIM DISCRETE EVENT SIMULATION SOFTWARE

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Declaration

This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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List of Abbreviations

JaamSim	Java Animation Modeling and Simulation
ADD	Assessment – Design – Development
GUI	Graphical User Interface

Abstrak

Projek ini merupakan pembelajaran dan pembangunan modul pembelajaran asas bagi sumber terbuka perisian simulasi peristiwa diskret yang bernama JaamSim ("Java Animation Modeling and Simulation"). Salah satu masalah yang selalu dihadapi oleh pengguna perisian simulasi ialah akses bagi perisian, terutamanya bagi pelajar yang susah untuk mendapatkan lesen perisian. Selain itu, bagi pengguna yang mahu belajar perisian simulasi baru, sumber pembelajaran yang ada adalah terhad. Dalam projek ini, perisian simulasi JaamSim telah dipilih kerana ia merupakan perisian sumber terbuka yang percuma. Ciri-cirinya juga setanding dengan komersial perisian simulasi peristiwa diskret yang lain seperti WITNESS. Secara amnya, projek ini telah dijalankan berdasarkan konsep "ADD" (Assessment-Design-Development). Pertamanya, keperluan pembelajaran pengguna perisian ditentukan melalui kaji selidik dalam talian. Sasaran responden kaji selidik ini merupakan pelajar dari Universiti Sains Malaysia (USM) yang belajar kursus Kejuruteraan Pembuatan dengan Pengurusan. Projek ini telah diikuti dengan analisis keperluan pembelajaran bagi pengguna perisian. Seterusnya, perisian JaamSim telah dikaji dan lima model simulasi telah dibina berdasarkan contoh di bidang pembuatan. Modul pembelajaran asas kemudiannya direka dan dibangunkan berdasarkan keperluan pembelajaran pengguna. Video bagi modul tersebut juga dibentuk melalui perisian "Powtoon". Akhirnya, modul pembelajaran asas yang dibentuk perlulah mencapai keperluan pembelajaran pengguna simulasi bagi perisian simulasi peristiwa diskret JaamSim.

Abstract (BI)

This project is about designing and developing a basic learning module of open-source JaamSim (“Java Animation Modelling and Simulation”) discrete event simulation software. One of the difficulties faced by the users when using simulation softwares is the accessibility of the software, especially for the students who were always struggling in obtaining the license of the softwares. Besides, for the users who wanted to learn new simulation softwares, the learning resources available are limited. In this project, JaamSim simulation software was being chosen as it is an open-source software which is free. Its features can be comparable with other commercial discrete event simulation softwares such as WITNESS. Generally, this project was conducted based on the “ADD” (Assessment-Design-Development) concept. First of all, the learning needs of the software users were being determined through online survey. The target of the survey respondents in this project were students from Universiti Sains Malaysia (USM) who are studying the course of Manufacturing Engineering with Management. The project was then followed by the analysis of learning needs of users. Next, the JaamSim software was being studied, and five simulation models were built based on the manufacturing examples. The basic learning modules were then being designed and developed based on the learning needs of users. Videos are also being made for the learning modules using “Powtoon” software. In the end of this project, the basic learning modules should reach the learning needs of the users when using JaamSim discrete event simulation software.

Chapter 1

INTRODUCTION

1.1. Project Overview

This project is about designing and developing a basic learning module for the new users for open-source JaamSim discrete event simulation software. Simulation software is basically a program which modeling the real phenomenon using a set of mathematical formulas, so that the final model will not have much deviation from the design specification. A discrete event simulation software models the operation of a system as a discrete sequence of events in time. Each event occurs at a particular instant in time and marks a change of state in the system. Open-source refers to the computer program in which the source code is publicly available for the use or modification of the program.

JaamSim (“Java Animation Modelling and Simulation”) is being selected in this project to design and develop the basic learning modules after making comparison of its specialities with the other discrete event simulation softwares. It is an open-source and cost-free simulation package which is written in the Java programming language. It provides a modern Graphical User Interface (GUI) such as drag-and-drop model building, an Input Editor, Output Viewer and three-dimensional (3D) graphics. All these GUI features are comparable to the commercial discrete event simulation softwares such as WITNESS and Matlab (SimEvents).

In order to design and develop the basic learning module, the learning needs of the simulation software users are required to be assessed. Online survey will be conducted to 30 USM students who are studying Manufacturing Engineering with Management course. Their survey results will be analyzed and their ideal-like learning method will be obtained. The content of the learning modules will then be designed based on the preferred learning method of target respondents. All the available resources will be gathered and the software will be studied in order to develop an effective basic learning modules. In the end, the performance of the basic learning modules will be evaluated and adjustments will be made if there is the occurrence of mistakes.

1.2. Problem Statement

One of the difficulties encountered by the simulation software users is the accessibility of the software, especially for the students. Students usually face the difficulty in obtaining the license for the commercial discrete event simulation software such as WITNESS and Matlab (SimEvents). Hence, the study and development of simulation model will be limited when it comes to proprietary software. JaamSim is one of the open-source discrete event simulation software which is not widely known among students. Therefore, for new beginners who are interested in learning JaamSim simulation software, it would be a difficult task as the learning resources is limited. There is not enough guidance and clear instructions for the new users. Hence, the design and development of an effective basic training module for the JaamSim discrete event simulation software is required in order to deal with the problem encountered.

1.3. Objectives

The objectives of this project are:

1. To assess the learning needs of software users when using discrete event simulation software.
2. To design and develop the basic learning modules and videos for the open-source JaamSim discrete event simulation software.

1.4. Scope of Work

First of all, a discrete event simulation software is being chosen based on comparison method. A few discrete event simulation softwares will be compared based on their features and specialities. The one with the best criteria among all discrete event simulation software will be the one to be studied in this project.

Generally, the project was being conducted based on the “ADD” (Assessment-Design-Development) concept. The project was started off by assessing the learning needs of the new users by conducting online survey. The target of the survey respondents were 30 students from Universiti Sains Malaysia (USM) who are studying the course of

Manufacturing Engineering with Management. The users' learning needs were then being analyzed and accounted in the design of the learning module.

Next, the JaamSim discrete event simulation software was studied and analyzed, together with the gathered resources, in order to develop an effective learning module. Five basic learning modules were being built, with the real examples or cases in manufacturing industries. The adjustment was being made to satisfy the needs of users in using JaamSim basic learning modules. Videos were also being made based on the five learning modules in order to enhance the learning speed of software users. In the end, the learning outcomes of the modules should reach the learning objectives and needs of the users in using JaamSim discrete event simulation software.

Chapter 2

LITERATURE REVIEW

2.1. Role of discrete event simulation softwares

Simulation plays a significant role in the manufacturing industries nowadays, where its importance is being discussed in the journal article of "*Simulation of manufacturing system*". Simulation is used to design the manufacturing system, as well as solve manufacturing issues faced and thus, improve the existing performance of the industries. [1] Discrete-event simulation is one in which the state of a model changes only at a discrete, but possibly random, set of simulated time points. In the journal article of "*Inside Discrete-Event Simulation Software: How it Works and Why it Matters*", the authors explained on how the discrete-event simulation software works using various implementation of discrete-event simulation software. Without such knowledge, the users might not take full advantage of the software's interactive tools or, might not even use the tools. [2]

2.2. Selection of discrete event simulation software

In order to evaluate the simulation packages and select the best one in company, the journal article of "*An Evaluation and Selection Methodology for Discrete-Event Simulation Software*" proposed a two-phase evaluation and selection methodology. The first phase is to select the packages based on the existence of most importance features and criteria. The detailed evaluation and analysis of the packages chosen are then done in the second phase. [3]

There are two common criteria being proposed in the journal article of "*Simulation of manufacturing system*" in selecting simulation software, which are the modeling flexibility and the ease of use. [1] Modeling flexibility refers to the ability of the software to model any system regardless of its complexity or uniqueness. Ease of use refers to the need of small amount of programming to build a model, where this criteria have given rise to the manufacturing-orientated simulator, which is a simulation package designed to model a manufacturing system in a specific class of systems. The two main characteristics of this type of software are the orientation of software is

towards manufacturing and there is little or no programming required to build a model. The advantage of using simulators is that the time required to develop the model will be reduced, however, they are not as flexible as simulation language, since they do not allow full-blown programming. One of the examples of simulators is the WITNESS software.

WITNESS simulation package is capable of modeling a variety of discrete and continuous elements. It is used to stimulate full production runs over an arbitrary time period. Its key feature makes the building simulation models in WITNESS to become highly productive. WITNESS allows users to design a facility and know how the production lines might operate in reality through simulation. However, WITNESS is one of the licensed software which keeps the source code hidden. [4]

2.3. JaamSim discrete event simulation software

On the other hand, JaamSim (Figure 2.1) is a free and open source simulation software that is comparable with the WITNESS software. It is Java based discrete-event simulation environment which is developed by Ausenco, a global engineering company. It is written in Java programming language, where it can be downloaded from Github. The target audience of JaamSim includes researchers, professionals and students. JaamSim is the first open-source simulation software which including a modern Graphical User Interface (GUI) that is comparable to commercial off-the-shelf simulation software. Its outstanding key feature is that users can create their own palettes of high-level objects for new applications, whereby the high-level objects refer to the objects that simulate the significant objects for a given class of model. Unlike the commercial simulation software, JaamSim is not restricted by any idiosyncrasies and limited feature set of a proprietary programming or scripting language. The number and variety of objects available in JaamSim in the time being will increase over time, and eventually emerge as an attractive alternative to commercial software for all users. [5]



Figure 2.1: Logo of JaamSim discrete event simulation software.

The features and tools are being introduced in the journal article of “JaamSim Described in Three Simple Examples”. The examples are given to demonstrate the features in JaamSim software, which shows that JaamSim offers an excellent user interface, modeling framework and 3D graphics. [6]

2.4. Advantages of using JaamSim Simulation Software in the Universities

There are a few advantages that could be obtained if JaamSim discrete event simulation software could be used in the Universities.

- **Accessibility of the software.**

JaamSim is an open-source discrete event simulation software. Since the license of JaamSim is accessible to everyone, the lecturers and students in Universities could easily download the software online, which increases the convenience of the users.

- **Cost of the software.**

JaamSim is a cost free discrete event simulation software. From the perspective of Universities, they do not need to spend money in obtaining the license of the software, as well as to pay for the upgrading and maintenance effort. The availability of JaamSim source code provides greater continuity and security against financial collapse of vendors of key products.

- **Performance of JaamSim software.**

JaamSim simulation software is many times faster than the commercial simulation software packages that offer a drag and drop interface. Besides, it is scalable to much larger and more complex models. For students who can obtaining mostly the educational version of simulation software license, there is limited objects or entities to be used. The models of JaamSim can be built up to 40,000 active objects, which is so useful to the students in their learning process.

In terms of the function of JaamSim discrete event simulation software, it could simulate the real life situation through data or specifications obtained. From the current model, the problem or difficulties encountered in the real phenomenon

could be observed. The improved model suggested is then being built based on the current model. The performance of the improved model is then being measured using the software in order to obtain the optimum result to be applied into the real situation. This software is useful especially to the manufacturing industries, as most of the decisions made requires cost and time effort. With this software, a decision could be made with its best justifications, as well as the decision-making time could be reduced. Students who have studied on how to use the JaamSim simulation software could apply their knowledge in their future career, helping to solve the problems in the industries.

- **Software flexibility and freedom.**

By using open source JaamSim software, it indicates that the Universities are not locked into using a particular vendor's system that only work with their other systems. JaamSim software provides flexibility through the freedom from a single vendor. From the students' perspective, they are flexible in using the free simulation software, which could widen their learning process. The proprietary softwares that have installed in Universities could limit their learning process, as the softwares might not be suitable for their needs.

The freedom in modifying the software causes the continuous evolving of JaamSim simulation software in real time, thus contributing to a better quality and more secure of the software. It indicates that the software is less prone to bugs than the proprietary systems, as many JaamSim users are weeding out problems continuously when they are using it.

- **Reliability of the software.**

When there is a detection of occurrence of severe defects, they tend to be fixed within hours due to the availability of source code. The able developers who discover the bug could fix it and report to the maintainers, as well as issue the updated version of software on their own authority. The software users can choose whether to use the unofficial fix or wait for an official version which is released by the project team itself. This mechanism works well in practice. On the other hand, the closed-source software will require the defect report to be

filled, causing a delay before the vendor determines when or whether to issue an updated release.

2.5. Importance of technology transfer through basic learning modules

In the journal article of “Understanding and Improving Technology Transfer in Software Engineering”, S.L. Pfleeger discussed about the process of creating, evaluating, packaging and diffusing technology. The success rate of the overall transfer for each activity is then being determined. He suggested ways to help both practitioners and researchers to understand the way to shorten the time between innovation and effective practice. This paper also shows the importance of the study of technology and the tools or method used in technology transfer. [7]

One of the approaches in technology transfer is the communication model. The communication model such as teaching or learning module could help to educate, and thus generate the teaching models. This kind of models can teach the others about the new technology after they have mastered it, which is also considered as another kind of technology transfer method. Hence, in this project, a basic learning module will be designed and developed for the open-source JaamSim discrete event simulation software, which is cost-free.

Chapter 3

RESEARCH METHODOLOGY

3.1. Flow Chart

The aim of this project is to assess the learning needs of the simulation software users, as well as to design and develop an effective basic learning module. A systematic methodology has been outlined in order to ensure that the progress of the project will be able to run smoothly and can be completed on time. (Figure 3.1)

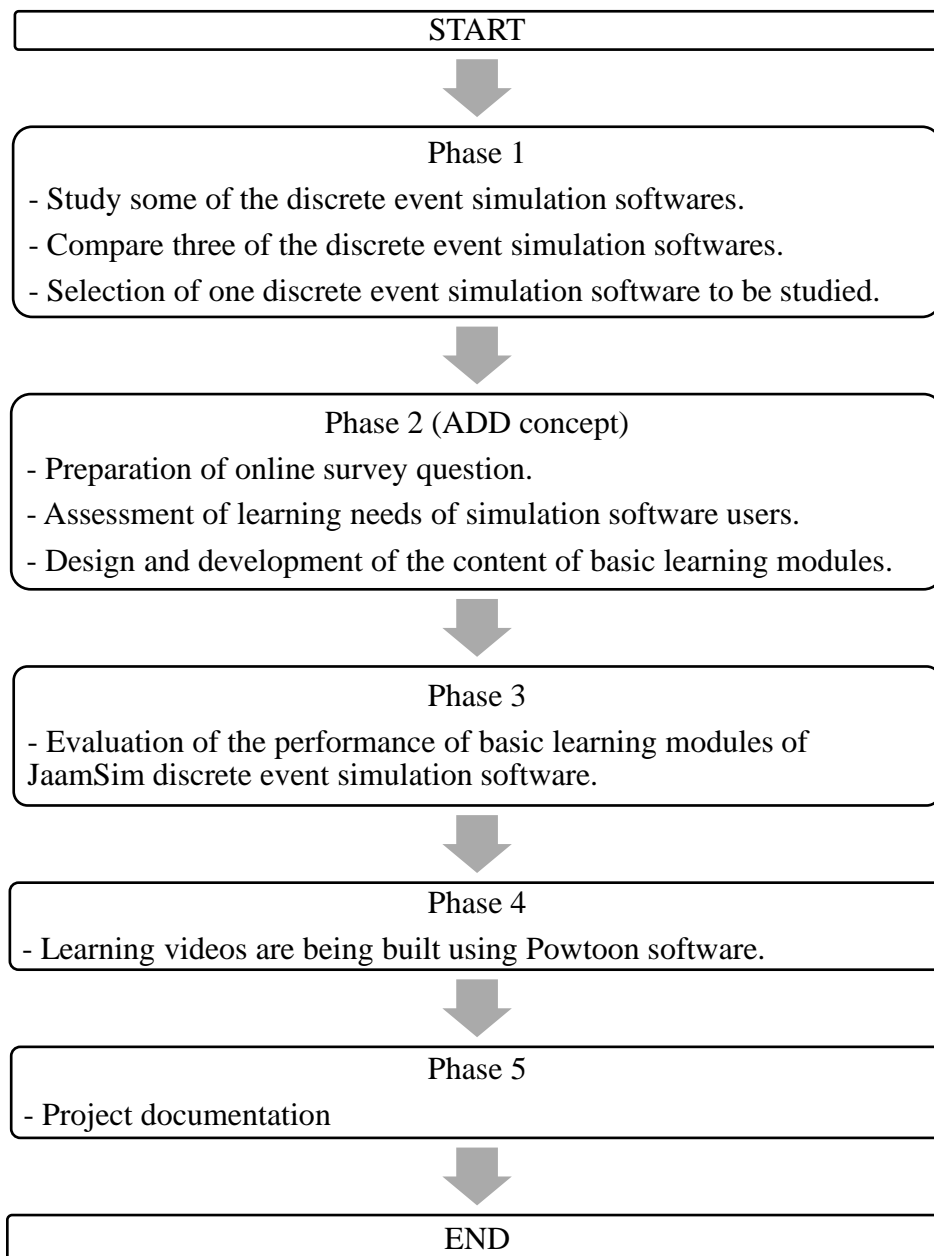


Figure 3.1: The flow chart of the research methodology.

3.2. Phase 1: Selection of the discrete event simulation software

A few discrete event simulation softwares are being compared and evaluated based on their features and specialities. The softwares that are being compared are JaamSim, WITNESS and SimEvents which shown in Table 3.1 below. [10]

Table 3.1: Comparison of discrete event simulation softwares.

Discrete event simulation software	JaamSim	WITNESS	SimEvents
Description	A framework for discrete-event simulation in Java, supporting animation in 2D and 3D.	A discrete-event simulation package that is mainly used to carry out the manufacturing simulation. It has an object-oriented modeling environment.	Adds discrete event simulation to the MATLAB or Simulink environment.
Language	Java	C++	Mixture of Java and C++
Support operating systems	Windows, OSX and Linux	Windows	Windows
Primary market	Researches, professionals and students.	Manufacturing, Oil and Gas, Healthcare, Nuclear, Defense	-
Usability	<ul style="list-style-type: none"> - Users can create their own palettes of high-level objects for new applications. - Not restricted by any idiosyncrasies and limited feature set of a proprietary programming or scripting language. 	<ul style="list-style-type: none"> - The concept of WITNESS is based on the Queueing Theory. - Programming itself involves the five most common elements (parts, machines, conveyors, buffers and labors). - The random number generator of WITNESS uses 	<ul style="list-style-type: none"> - SimEvents adds a robust discrete event simulation capability to the already extensive Matlab product. - Support and documentation are excellent. - Debugging capabilities are limited.

	- The number and variety of objects available in JaamSim in the time being will increase over time.	6 seeds to generate or alter random numbers. - Limited use of number of objects in educational version.	
Is student license free?	Yes	No	No (USD 3,750 per individual)
Last updated	May 2, 2017	-	September 14, 2016

Based on the comparison details in Table 3.1, JaamSim discrete event simulation software is being selected to be studied in this project as it has outstanding features and specialities compared to WITNESS and Matlab (SimEvents) softwares. As the software used is dedicated more towards the universities perspective, hence the advantages of using discrete event simulation software in the universities should be accounted when selecting the suitable software among all these choices. [8] JaamSim has the best features among all which includes:

- **JaamSim is an open-source and cost-free software.**
WITNESS and SimEvents are the proprietary simulation softwares that do not provide open source code and requires cost in order to use them.
- **JaamSim is not restricted to the use of number of objects in the software.**
For WITNESS simulation software, its educational version will restrict the users from using more than 25 objects in building the simulation model, which will limit the learning process of users. SimEvents do not have restriction on the number of objects used in the software.
- **JaamSim can create highly complex objects which is easy to be understood.**
Due to the limitation on number of objects used in educational version, WITNESS software could not create detailed complex objects as JaamSim software. For SimEvents, its simulation model built is difficult to be visualized by new software beginners or outsiders who wanted to understand about the