An Interactive Data Analytics and Visualization Web-App for Rapid Statistical Process Control Analysis

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ABSTRACT: Statistical process control (SPC) implementation plays a major role in the quality assurance during the manufacturing process. Nevertheless, the adoption rate of SPC commercial software solution is unsatisfactory in most Malaysian manufacturing companies due to high subscription costs and difficulties to apply the software without proper guidance and training. This study proposes the development of purpose-built interactive data visualization web-app for rapid SPC analysis using open-sourced software packages. Agile software development model is applied as the chosen software development methodology. The developed web-app can assist users, particularly from the industrial sectors, to perform fast SPC data analytics, visualization and reporting with ease.

Keywords: *Statistical process control; Data analytics, Interactive visualization; Manufacturing*

1. INTRODUCTION

Nowadays, manufacturing companies are facing fierce market competition to offer quality products with shorter time-to-market. In relation, statistical process control (SPC) analysis is one of the common strategies that is widely used in manufacturing industries for such a purpose. From literature survey, SPC is commonly applied through commercial software packages, apart from manual charting or spreadsheet application (Abtew et al., 2018). However, a study by Rahman et al. (2009) showed that while large Malaysian manufacturing companies are able to afford commercial software packages, it is difficult for small and medium enterprises (SMEs) to follow such a practice due to several factors, e.g. knowledge and training requirements and cost of ownership. In fact, in the context of Malaysian manufacturing sector, the adoption rate of SPC software packages is low mainly due high cost of software licensing, maintenance and customization features (Rohani, 2015). There is a need for these companies towards affordable computer-based or web-based SPC application, that possess a friendly user interface (UI) design and good functionality (Zain et al., 2009). This paper presents the design and development of a SPC Web-App in an attempt to address the aforementioned challenge. The Web-App features an easy to use UI that enables interactive SPC data analytics, visualization & reporting. We shall detail the design and development of this Web-App in the following sections.

2. Interactive Web-App for SPC Analysis

In this study, agile software development is adopted as the chosen software development model. The details of each phase under the methodology shall be explained in the following sections.

2.1 Requirement Phase

The first phase of the software development phase is requirement analysis. The aim of this phase is to identify the actual needs of potential end users, which includes identifying the scope, design problems, and requirements of the SPC Web-App. In the requirement phase, an interview session was conducted with two stakeholders (i.e. industrial practitioners) to identify the project requirement. Among the needs identified from this stage are as follows: application access without installation, able to detect outlier data quickly during SPC analysis, interactive parameter control (e.g., sigma option, sample size, frequency, etc.), interactive visualization of analysis results and also reporting / export feature. All these requirements are considered during the design phase.

2.2 Design Phase

Based on the feedback and expectations from stakeholders, design phase aimed to propose practical design for the application. For ease of access without installation, Web-App is determined as the best option. Factors considered during this phase are such as design suitability, UI layout design and functionality of the Web-App. Consistency in UI elements, along with other considerations such as simplicity, prompt status feedback and user in-control, are emphasized during the UI design. Besides the basic SPC analysis elements such as mean, standard deviation, upper control limit and lower control limit to detect the out of control in production process, specific functionality such as X-bar chart visualization using using control parameters such as sigma slider, column selection, row selection, sample size, and subgroup frequency are incorporated. Visualization changes in SPC analysis results will be updated in accordance to different parameter control. Besides, UI customization such as such as color customization, as well as automated reporting features is also available. Figure 1 indicates an example of the Web-App's UI design.

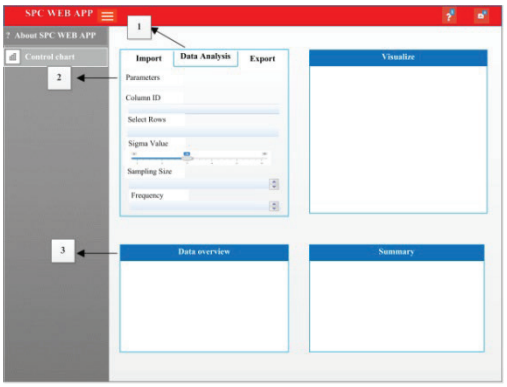

Figure 1 Example of UI Design: (1) Data Analysis Tab (2) Interactive Parameter Control (3) Raw Data Import Overview

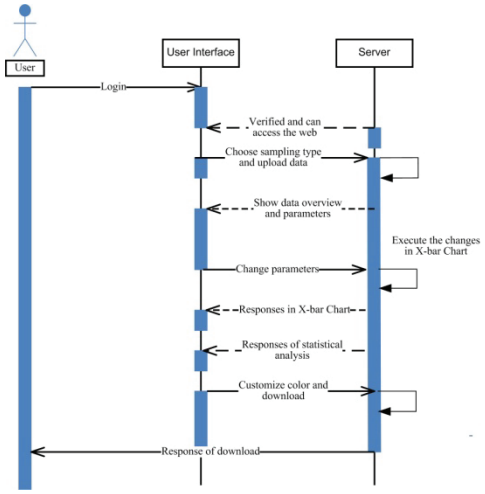

Figure 2 UI Interaction in UML Sequence Diagram

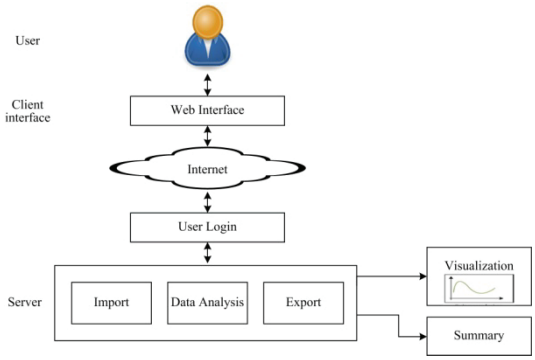

Figure 3 System Architecture

2.3 *Development Phase*

The development phase illustrates how the Web-App is being developed. In this phase, practical features such as user login, buttons and navigation design are being materialized. Figure 2 illustrates the UI interaction design that is considered during this phase in UML notation. The interaction is designed to let users navigate the Web-App with ease. Figure 3 shows the overall system architecture that is consists of two-layered web-based implementation: client interface layer and web server layer. Client interface is designed to help the user easily carry out tagging functions such as log-in process, selecting parameters for control chart and notification as instruction video and feedback form. Server layer serves as back-end of a web app which handle multiple functions such as perform statistical analysis, plot and visualization, reporting, and output tasks which enables the user to interactively use this web application. There are five modules to establish the server layer function. For instance, import, data analysis, visualization, export, and summary.

The entire Web-App is developed by using R as the base scripting language, with plugin of several library packages such as Shiny & ggplot2, and Rstudio as the IDE tool for programming. Technical wise, the development of the Web-App involved the programming of two scripts: (1) User interface script that enables the user interaction with the Web-App such as buttons, dropdown list, navigation component, etc., and (2) Server script that function as computational module for analysis, visualization and reporting feature of the Web-App.

2.4 *Testing & Deployment Phase*

After the software development, testing phase is entered where the Web-App undergo the debug and validation process to ensure error free operation. The software testing is performed using an automated testing tool, Shinytest within the Shiny package in R. Upon validation and debugging, The Web-App is deployed online as a web application in RStudio server ShinyApps.io. The Web-App has been successfully deployed and is accessible online[1].

3. CONCLUSION

This study has successfully design and developed an interactive data analysis and visualization Web-App for SPC analysis with all the required features. Overall, the development and deployment of Web-App has been successful. The next phase of this project is to see how developed Web-App can assist industrial practitioners to perform rapid SPC analysis, visualization and reporting.

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