Improvement of Quotation Process for a Large Transformer Manufacturer

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Abstract. There are so many activities involved in quotation for a large transformer manufacture, it is made up of thousands of components and it take a lot of time to go through the process, including reading request for quotation, conceptual design, figure drawing, materials price inquiry and cost evaluation, it is difficult to maintain the accuracy and it might cause large amount of loss if the process goes wrong because quotation plays a vital role in order obtaining. Therefore, it is important for the company to figure out how to enhance the efficiency of quotation. Industry 4.0, has become one of the most popular concepts since 2012 which is proposed by German government, the core concept is automation and intellectualization in manufacture industry by integrating the advanced technologies. This research suggest an improved process which shorten the time of quotation and automatic classification system based on neural network algorithm for a large transformer manufacture to raise the efficiency and accuracy for quotation and, the possibility for winning orders will also increase.

Keywords. quotation, neural network, document classification, automation

1. Introduction

Industry 4.0 is a concept proposed by Germany "High-Tech Strategy 2020 Action Plan" in 2012, it aims to enhance the degree of digital, intelligence and computerization in manufacturing and establish a highly adaptive and efficient environment to achieve a comprehensive networking process. Industry 4.0 is made up of nine main technologies, the core technologies consist of Cyber-Physical Systems (CPS), Industrial Internet, cloud computing and big data. If a company can introduce the concept of Industrial 4.0, the efficiency of business process will be raised significantly. For a company to obtain customer orders, conceptual design for quotation is always the first step. After the company for open bit receives the specifications from an industry customer, they will conduct preliminary conceptual design and cost analysis based on historical data and past experience, after quoting price, the customer will decide the winning vendor. Therefore, how to raise the efficiency and accuracy of quoting price to obtain the bidders’ order is a very important issue. Quote phase includes complicated several steps such as specifications preview, price

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inquiries and cost analysis and control, there are also many different suppliers and customers should be considered, even the delivery will affect the quoting results. A lot of information that needs to be utilized properly, if all these elements can be managed effectively and make the best use of existing information, the company can work out an accurate quote quickly to enhance its competitiveness. A large transformer is made up of thousands of parts, and it cannot be completely standardized, it need to retain a certain degree of customization so it is difficult to maintain the accuracy and efficiency in the quote phase, therefore, this research will use a large transformer manufacturer as example and discuss the quotation process improvement toward industry 4.0 objectives.

2. Literature review

This section will introduce the definition and relative literature of document classification, key phrases extraction and neural network algorithm.

2.1. Document classification

Document categorization is a crucial and well-proven instrument for organizing large volumes of textual information. Comprehensive classification systems have been developed and maintained by librarians since the 19th century and are today in widespread use. The advent of the Web and the enormous growth of digital content in intranets, databases, and archives, have further increased the demand for categorization. In the face of the pace and complexity of this process, manual categorization often lacks economic efficiency and automatic tools are indispensable to supplement human efforts. Document classification is a process which assign documents to one or multiple predefined categories, it contains two main steps: file parsing and classify, as Figure 1 shows. Cohen, Aaron M., et al. (2006) how to enhance the efficiency for systematic review preparation. They built a system to determine whether automated classification of document citations can be useful in reducing the time spent by experts reviewing journal articles for inclusion in updating systematic reviews of drug class efficacy for treatment of disease. They concluded that automated document citation classification could be a useful tool in maintaining systematic reviews of the efficacy of drug therapy. Aurangzeb, Baharum, Lee and Khairullah (2010) noted that the steps of document classification contains read the document (tokenize text, stop words and stemming), feature selection vector presentation and learning algorithm. Kim and Choi (2007) use document classification which is based on k-NN (k-Nearest Neighbor) approach in Japanese patent files and found out 74% improvement of categorization performance that does not use the structural information of the patent.
2.2. Key phrases extraction

Key phrase extraction is considered as an important step prior to the document classification. Request for quotation documents are usually described in a lengthy written explanation and hard to understand the specification or main materials in short period of time. In addition, text mining methodology has been applied to extract key phrases from patent documents. Term frequency (TF) and inverse document frequency (IDF) are two major factors used in text collection and information retrieval. TF measures the occurrence frequency of a specific term in a document [9]. IDF presents the rarity of the term in a set of documents [10]. Salton and Buckley suggested that using TF-IDF method can find out the representative terms in a document based on how frequently they appear across a collection of documents [11]. However, TF factor does not take account of the length of documents. The normalized TF (NTF) approach considering document length and word counts can be applied in this research [7].

2.3. Neural network

Neural networks is a dynamic computing system, the initial concept is proposed by McCulloch and Pitts (1943). Neural networks is composed by three kinds of node (neural), input nodes, hidden nodes and output nodes. The process can be divided into three phases, learning, recall and induction, and have been applied to a very broad range to achieve many different goals. Generally, analysis of classification problems is one of the most mature areas of neural network research. Due to the raise of computer operating speed, the efficiency of neural network is also increasing, therefore, there are many researches about applying neural network to document classification. Wantao Deng and Wu (2007) used neural network algorithm to build a new document classification method (Growing Cell Structures, GCS). The electrochemical process of a neural networks is like a voltage-to-frequency translator (Anderson and Rosenfeld, 1987). The inputs to the neuron cause a chemical reaction, when the chemicals build to a certain threshold, the neuron discharges. The literature has shown that neural networks have been applied to control nonlinear systems. There has been a large body of paper applying neural networks for controls, but most of the papers do not address initial performance, reinitializing the weights, the randomly-initialized weights, incorporating a priori information, or time to convergence. These issues are very important.
if an effective controller is to be developed.

**Figure 2.** Neural network

### 3. Methodology

This section will suggest an improved process of quotation for the case company, the methodology consists of two parts. First review the original process and improve it by introducing the concept of automation and intellectualization. Second, design a computerized system based on neural network algorithm to reach achieve the improved process. The quotation process of the case company (As-is process) is shown in Figure 3. First, the RFQ is read and recorded by engineers. After conceptual design, prototype figure is drawn. Then the process goes through main materials price inquiry, other components inquiry, labor cost evaluation and total cost evaluation.

**Figure 3.** Quotation process of case company (As-is model)
Figure 4 shows the detailed step of conceptual design, in this step, engineers will construct a preliminary design chart based on the key phrases and evaluate the weight of this design, the final step is to make the chart approved then goes to the next step.

![Diagram showing the conceptual design process]

**Figure 4.** Drill down of conceptual design (As-is model)

Figure 5 shows the detailed step of main materials and other components inquiry. Once the design chart is approved, the purchasing executive will check whether there are inventory in the warehouse, if not, the company will evaluate the cost of manufacture by itself and ask suppliers for quotation, then make the final decision.

![Diagram showing the main materials inquiry process]

**Figure 5.** Drill down of main materials and other components inquiry (As-is model)

### 3.1 Improved process of quotation

The original steps of quotation contains RFQ reading, conceptual design, prototype figure drawing, components price inquiry and cost evaluation, all of these steps are done manually so far, the human error rate is very high and it cost a lot of time and labor to complete one certain step. Therefore, this research recommend an improved process for quotation which is
shown in Figure 3, before this process is implemented, an automated classification system should be developed.

![Diagram of classification process](image)

**Figure 6.** Process of document classification

Drill down of Import RFQ into classification system is shown in Figure 4. In this step, RFQ documents are first input into the classification system, and they will be parsed and classified automatically, it can save lots of cost and reduce the possibility of human error.

![Diagram of Import RFQ into classification system](image)

**Figure 4.** Drill down of Import RFQ into classification system

Drill down of Compare with historical data is shown in Figure 5, after RFQ were classified, the system will compare the specifications with the historical documents and crawl the previous price information of materials, it save the time of price inquiry for each components.

![Diagram of Compare with historical data](image)

**Figure 7.** Drill down of Compare with historical data
3.2 System design

This section propose design concept and interface of the automatic system to reach the goal of this research. First, RFQ documents have to be uploaded to the page shown in Figure 8, and they will be classified and recorded into the database as a historical information at the same time.

![Figure 8. Page of uploading RFQ](image)

Figure 9 shows the data model used for quotation, it needs RFQ data sheet which shows the all specification including case ID, customer name, type, frequency, noise and voltage etc. Customer information is also needed in quotation phase and one customer can correspond to many RFQ.

![Figure 9. Data model used for quotation](image)
After the RFQ were uploaded, RFQ record page can be generated automatically by extracting the key phrases of the request for quotation, all the specification will be present in the page shown in Figure 10.

The users can also read the historical RFQ information, the previous data can be deleted or edited manually, the historical information page is shown in Figure 11, all of the data columns can be corresponded to the data sheet in Figure 9.
Once the specifications are confirmed and submitted, the system will compare the similarity with the historical data, the higher similarity rate means they belong to the same class, the page is shown in Figure 12.

**Figure 12. Historical RFQ information**

Figure 13 shows the historical request for quotation information, the difference will be highlighted so that the users (experts or engineers) can understand immediately, the final quotation price of historical RFQ will also be shown, the efficiency of total cost evaluation can be raised.

**Figure 13. Historical RFQ information**
After the completion of the previous steps, the specifications are confirmed, the parameters will be imported into the intellectual graphing system which might be auto-CAD or other graphing-related software. The approver can revise or adjust the specifications manually so that the detailed of the figure can be more accurate. The page of automated graphing system is shown in Figure 14.

![Automated graphing system](image)

**Figure 14.** Automated graphing system

4. Conclusions

Since quotation is a very first and the most important phase in a business, this research uses the concept of in industry 4.0, automation and intellectualization to improve the quotation process for a large transformer manufacturer. A new process model is proposed and also offer
a direction and interface concept for designing an automated quotation system. The system applied neural network algorithm to classify all the request for quotation (RFQ) in a very short time, and all of the data (key phrases, specifications) in RFQ will be recorded in the database, if a new RFQ is imported, the system can compared the similarity with old ones, it can save a lot of cost caused by labor and time, also, the key phrases are defined by expert (engineer) so that the chance to occur an error is very low. If the case company can develop the system and apply the new process suggested by this research, the efficiency and accuracy of quotation can be raised so that the company is more competitive.

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References