Verbal Communication Quality Analysis of Human Operators in Main Control Room

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1. Introduction

Verbal communication problems have been one of the major human factors causing serious problems in many industries [1]. The results of existing researches have revealed that keeping good communication quality is essential to ensure the safety of a large-sized and highly advanced industrial process system [2][3]. Communication Quality is ensured only when both parties involved in a communication process understand and comprehend each other correctly, and it can be decided based on the correctness of the messages communicated between them. In this paper, we suggested a method to measure the quality of communication during off-normal situation in main control room of nuclear power plants. It evaluates the cosine similarity that is a measure of sentence similarity between two operators by finding the cosine of the angle between them.

2. Methods and Results

2.1 Measuring verbal Communication Quality

The main goal of this research is to develop an evaluation framework that assesses the similarity in the content of the conversation generated to perform response operations under off-normal situations. The similarity evaluation logic is a technique that expresses the similarity inside conversation sentences derived from the result of the calculation of the distance between each vector, and whose basis is well established in the area of mathematics and has been adapted in various fields, and which, especially, is widely being used in areas like computer engineering, internet search, and more [4].

The following equation represents an operator's sentence similarity estimating method using the concept of cosine similarity at a vector space model [5].

$$\cos(D_i, Q_j) = \frac{\sum_{k=1}^{t} d_{ik} q_{jk}}{\sqrt{\left(\sum_{k=1}^{t} (d_{ik})^2 \sum_{k=1}^{t} (q_{jk})^2\right)}}$$

Here, D and Q mean the dialogue sentences exchanged between each operator.

2.2 The Evaluation Framework

Figure 1 explains how the communication quality evaluation is carried out: statistical treatment of the evaluation results in respect of all duties will be performed after collecting data, processing data, and evaluating the similarity of dialogue sentences per unit duty after separating the processed data from each unit duty.

The procedure to evaluate the communication quality between operators consists in 4 major steps as follows:

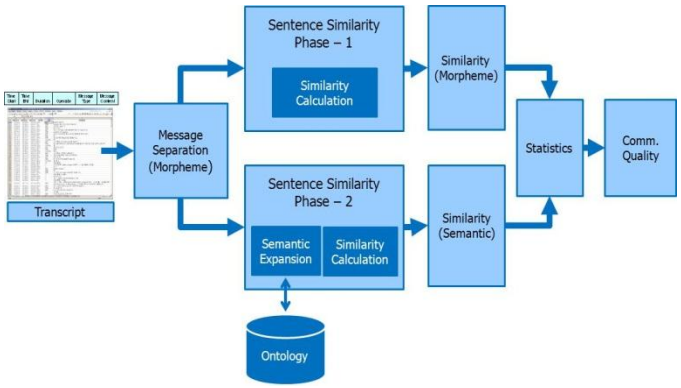

Fig. 2. Communication Quality Evaluation Frameworks

The first step is a preparation phase to carry out the practical evaluation of communication quality by obtaining the dialogue data between operators, which is largely composed of the following steps: i) recording experimental data, ii) transcription, iii) classification of messages (duration of dialogue, speaker, message type, content of message)

The second step is an evaluation phase of sentence similarity by dint of sentence morpheme separation which is the first step of the similarity evaluation of dialogue between operators.

The third step is the second phase of similarity evaluation of dialogue, which is the similarity evaluation phase through the expansion of sentence synonym.

The fourth step is a statistical treatment of the evaluation results of dialogue similarity between the operators gained from the second and the third steps in order to accomplish the final similarity.

2.3 Evaluation and Results

In the training center of the YGN3&4 NPP, a full scope simulator is installed with conventional control panels and alarms. All kinds of operator activities, (such as valve or pump operations) including communications among the crew members, can be recorded on videotapes. The record collection period was the first

half of 2008. During this period, in total, 5 re-training records performed by different teams were collected by video recording. From the collected records, the verbal protocol data of each re-training sessions were created for communication quality evaluation.

Table1 and Figure2 display the result of the performance and the evaluation results of similarity of each team in a graph.

Table 1 Results of communication quality analysis

Team ID	Perfor-mance	Similarity (Morpheme)	Similarity (Semantic)	Similarity (Mean)
#1	84	38.29%	73.58%	55.94%
#2	80	39.37%	74.51%	56.94%
#3	84	41.70%	71.73%	56.72%
#4	70	31.64%	61.88%	46.76%
#5	72	36.00%	61.67%	48.84%

The evaluation result analyzed the relationship between performance and similarity into two groups, the high-ranking 3 teams with good performance show relatively better results in dialogue sentence similarity, on the contrary, the low-ranking 2 teams with poor performance show relatively low points in sentence similarity. Therefore, a linear correlation between performance and similarity can be determined.

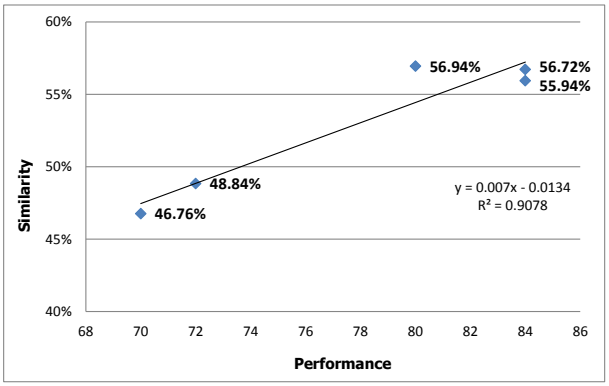

Fig. 2. Performance and Similarity Analysis

3. Conclusions

A Framework to measure the communication quality of crews in the main control room has been suggested in this research.It evaluates the cosine similarity that is a measure of sentence similarity between two operators by finding the cosine of the angle between them. To check the applicability of the method to evaluate communication quality, and the result of a communication quality analysis and the result of the performance of operators under a simulated environment were compared.

According to the results of the communication quality evaluation, it was demonstrated that operating teams with high communication quality showed good operating performance while operating teams with low communication quality had poor operating performance.

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