Integrating Culture Intelligence into Computer Science

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Abstract - *Research on Cultural Intelligence provides a new perspective and promising means of reducing intercultural conflicts and obstacles. Up until now, research in this domain has used traditional methods and has relied mainly on questionnaires to manually evaluate the Cultural Intelligence of individuals. This research aims to invent a Cultural Intelligence evaluation computational model which implements the model in an expert system, in order to evaluate precisely the Cultural Intelligence of individuals and organizations through the use of Artificial Intelligence technology. The purpose of this system is to support users in solving the intercultural adaptation problems that they face in various authentic situations. As a 'culturally aware' intelligent evaluation system, this system can be used to evaluate individuals and organizations in Cultural Intelligence training, and provides specific suggestions to improve their weaknesses in the corresponding area. This is a particular importance in modern learning theories.*

Keywords: Cultural Intelligence, Evaluation System, Fuzzy logic, Artificial Neural Networks, Hybrid Neuro-Fuzzy Intelligent System

1 Introduction

In the context of globalization, individuals are required to make culturally relevant decisions and to show their competence in culturally diverse workplaces. Once in a foreign country, some individuals can easily and successfully integrate into the local culture. In contrast, others find it difficult or impossible to adapt to a new context. Why does this difficulty exist? What do people need in order to rapidly and effectively adapt to a new culture? What can be done to improve people`s capacity to adapt to a different culture?

In recent years, more and more cultural experts and researchers have shown great interest in intercultural communications. They believe that a person`s extent and development in their capacity of cultural adaptation are more important, more accurate and more effective than simply transmitting different cultural knowledge to a person. This adaptation ability in different cultures to a person is called Cultural Intelligence (CQ) [1]. Thus, the CQ is presented as a new phenomenon of effective solving problems of cultural conflicts. Since it was proposed, organizational psychology and human resource management have given it much attention.

However, studies on the CQ are currently performed with manual processing. In this study, we propose at first a CQ computational model, and then we implemented the model in an expert system based on an innovative breed of AI technologies, to evaluate individuals and to give them recommendations to improve their CQ, so that they can appropriately interact with different cultures. This system has three main functions: one function is to precisely assess an individual`s CQ skill level; the other is to provide concrete recommendations; while the third is to facilitate researchers` work and to equip them in their research concerning CQ. The system is considered highly intelligent due to its wealth of knowledge, openness, scalability, flexibility, adaptability, and capability to self-learn. As a result of these qualities, the system allows better interaction and more effective aid in the evaluation process so as to improve users' cultural skills in different cultural settings

2 Cultural Intelligence

In the research literature, Earley and Ang presented CQ as a reflection of people's ability in a new cultural context to collect and process information, to make judgments, and to take effective measures to adapt [2]. Earley and Mosakowski later redefined CQ as what a manager refers to as his ability to deal calmly with different cultures [3]. Early and Mosakowsi stressed that people with a relatively high CQ level often appear at ease in new situations. They understand the subtleties of different cultures, so they can avoid or resolve conflicts early.

Peterson interprets CQ in terms of its operation [4]. He believes that, for the concept of CQ, the definition of 'culture' is compatible with the cultural values of Hofstede and their five main dimensions [5]. Peterson also describes CQ as the communicative capabilities which improve working environments. In other words, all the workers have the ability to communicate efficiently with customers, partners and colleagues from different countries in order to maintain harmonious relationships.

Ang and al. define CQ as the conceptualization of a particular form of intelligence based on the ability of an individual to reason correctly in situations characterized by cultural diversity [6]. They suggest that CQ is a complementary form of intelligence which may explain the ability to deal with diversity and function in a new cultural setting.

Earley and Ang are pioneers in the development of CQ concepts by having created a three-dimensional model in 2003. Ang and Van Dyne later refined this concept to consist of four dimensions structure rather than three. This structure has been widely used in the following cultural research and studies. They paid special attention to how a culturally diverse environment works [6].

1) Metacognition refers to the cognitive ability of an individual to recognize and understand appropriate expectations in different cultural situations. It reflects the mental processes that an individual uses to acquire and understand cultural knowledge.

2) Cognition is a person's knowledge of the standards, practices and conventions in different cultures which he/she acquired from education and personal experiences.

3) Motivation refers to the motivation of an individual to adapt to different cultural situations. It demonstrates the individual's ability to focus his/her attention and energy on learning and practicing in culturally diverse situations.

4) Behavior is defined as an individual's ability to communicate and behave with cultural sensitivity when interacting with people of different cultures. It represents a person's ability to act and speak appropriately (i.e., use suitable language, tones, gestures and facial expressions) in a given culture [7].

3 Cultural Intelligence Computational Model

3.1 Data Acquisition

Kon et al. [7], Ang et al. [8], and Ang et al. [6] developed a self-assessment questionnaire which has 20 items that measure CQ. This questionnaire was used to collect data for studies on the capabilities of the test subjects regarding their cultural adaptation capacity. This questionnaire is generally divided into four sections: metacognitive, cognitive, motivational and behavioral. For example, one of the items is "*I am conscious of the cultural knowledge I use when I interacting with people with different cultural backgrounds*." Van Dyne et al. [9] developed a version of the questionnaire from the point of view of an observer. It is also based on the 20 items of Ang et al. [6] in order to measure the CQ of individuals. The questionnaire was adapted from each item of the self-assessment questionnaire to reflect the assessment made by an observer rather than the user himself. For example, the item of the questionnaire shown above changes from: "*I am conscious of the cultural knowledge I use when…*" to "*This person is conscious of cultural knowledge he / she uses when* ...." As explained by Van Dyne et al. [9], these questionnaires allow for the effective assessment of CQ in practical applications. Thus, we adapted the self-assessment questionnaire of Ang et al. [6], along with the observer questionnaire by Van Dyne et al. [9] to measure CQ in order to integrate the evaluation functions offered by our model.

3.2 AI Technologies

The model is made up of a combination of two AI technologies, which makes it possible to achieve a CQ system capable of providing better evaluation and improving the adaptability of individuals in intercultural settings. The two main technologies employed are: 1*) Hybrid Neuron-Fuzzy Technology*: fuzzy logic is used when the natural language describing the concepts of CQ is ambiguous and imprecise; Although the fuzzy logic technology has the ability and the means of understanding natural language, it offers no mechanism for automatic rule acquisition and adjustment. The Artificial Neural Network (ANN) technology is an adaptive system that can be formed and adjusted from a set of samples. The ANN can handle new data input with the generalization of acquired knowledge. Thus, hybrid neuro-fuzzy is used as it combines and makes use of the advantages and power of fuzzy logic and ANN, which are complementary paradigms. *2) Expert System (ES)*: A knowledge base which allows knowledge engineering to transform expert cultural knowledge using fuzzy logic, such as the basic knowledge of law, economics, is also required. The ES was, therefore, chosen as the second technology. An ES cannot learn, but it can explain its reasoning. The combination of these technologies allows us to attain the technical aspects, as per our system development requirements.

3.3 Creating Fuzzy Sets

All the fuzzy sets come from the CQ domain. A practical approach to form fuzzy sets is used in our model. We take the first dimension of CQ *Metacognition* as an example (See section 2), when *X* is the universe of discourse of metacognition, and its elements are denoted as *x*, the fuzzy set *Metacognition (MC)*, is part of the universe *X* and is defined by the function $\mu MC(x)$ as a function of membership in the set *Metacognition*. This equation is expressed as: $\mu MC(x): X \rightarrow [0,1]$. For every element *x* of universe *X*, the membership function $\mu MC(x)$ equals the degree to which *x* is an element of set *Metacognition*. This degree, with a value between 0 and 1, represents the level of membership of element *x* to set *Metacognition*.

As our model is also based on ANN technology, our second approach to form fuzzy sets is to learn from the data available to the CQEES, and then to derive the fuzzy sets automatically.

3.4 Fuzzy Rules and Operations of Fuzzy Sets

The idea of linguistic variables is one basis of the fuzzy set theory. A linguistic variable is a fuzzy variable. For

example, when we say "*the Cultural Intelligence is high*," it means that the linguistic variable of CQ takes the linguistic value *high*. Thus, our linguistic variables are used in fuzzy rules in the model. For example:

Rule x:

IF Metacognition is high AND cognition is high AND motivation is high AND behavior is high

THEN CQ is high

Rule y:

IF Enjoys interacting OR confident to socialize with people from other cultures OR likes living in different cultural settings OR confident in himself OR handles stress well in cultural adaptation

THEN Motivation is high

The operations of fuzzy sets used in our model are the *Intersection* (AND) and *Union (*OR*)*. For example, the fuzzy operation used to create the *Intersection* of two fuzzy sets A and B is as follows:

$$\mu A \cap B(x) = min[\mu A(x), \mu B(x)] = \mu A(x) \cap \mu B(x), where\ x\ \in X \quad (1)$$

The operation to form the fuzzy *Union* of two fuzzy sets A and B is as follows:

$$\mu A \cup B(x) = max[\mu A(x), \mu B(x)] = \mu A(x) \cup \mu B(x), where\ x \in X \quad (2)$$

Considering two fuzzy sets of *High Metacognition* and *Medium Metacognition* of a person (between 0 and 10):
High metacognition = (0.1 / 1, 0.7 / 7, 0.9 / 9);
Medium metacognition = (0.5 / 1, 0.3 / 7, 0.1 / 9)

According to equation (1), the *Intersection* of these two sets is:

High metacognition ∩ *Medium metacognition* = (0.1/1, 0.3/7, 0.1/9)

According to equation (2), the *Union* of these two sets is:

High metacognition U *Medium metacognition* = (0.5/1, 0.7/7, 0.9/9)

3.5 Applying AI Technology to Model

This model is based on the theory of Ang et al. [6] and its four dimensions of CQ: metacognition, cognition, motivation and behavior, as well as the other most important aspects. We agree that the four dimensions are critical factors that can help individuals and organizations to overcome cross-cultural challenges. Thus, we applied the four dimensions in order to integrate the elements required to respond to the CQ evaluation cultural knowledge acquired in cross-cultural activities.

The neuro-fuzzy model is similar to a multilayer neural network. The model uses a technique called the fuzzy inference method by Mamdani [10]. Fig.1 illustrates in the model an example of the application of the technique by using triangular sets. We define that the fuzzy system as having four inputs: *metacognition*, *cognition*, *motivation*, and *behavior*, and as having one output: CQ. For example, input *metacognition* is represented by metacognitive fuzzy sets 1,2,3,4,5,6; output CQ is represented by fuzzy sets CQ 1, 2,3,4,5 and 6.

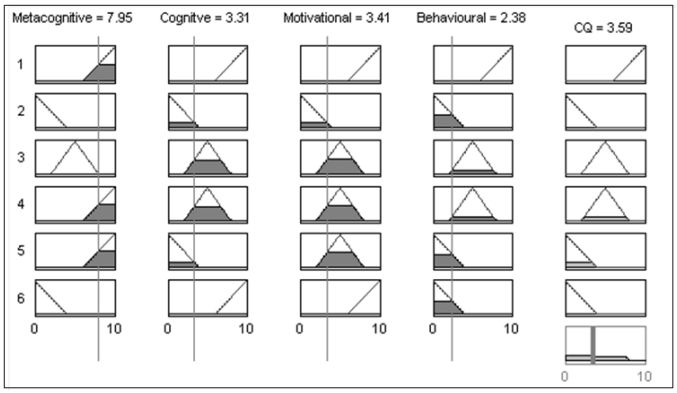

Figure 1. Example of the fuzzy inference system of Mamdani using triangular setsCQEES

Fig. 2 shows the neuro-fuzzy model that corresponds to this fuzzy inference system. It is represented with a neural network composed of five layers in the model. Each layer of the neuro-fuzzy inference model is associated with a particular step in the fuzzy inference process (See Fig.1). It also has four inputs: *metacognition* (MC), *cognition* (C), *motivation* (M) and *behavior* (BEH), and has one output: CQ

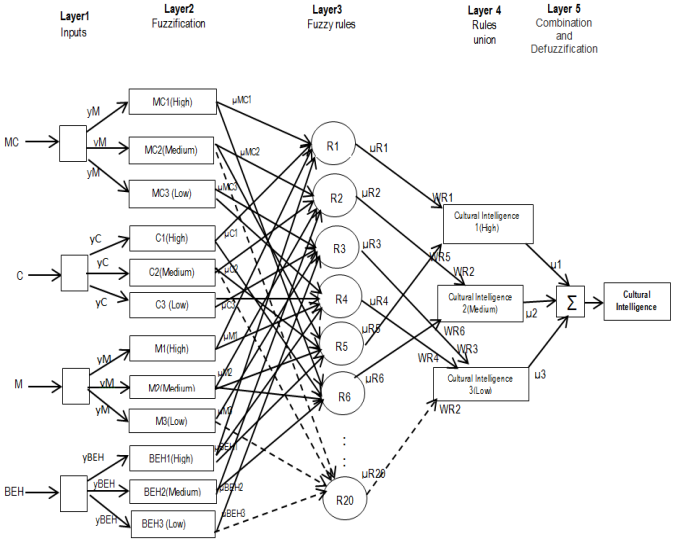

Figure 2. Five layers CQ computational model

Layer 1 - Input: No calculation is made in this layer. Each neuron corresponds to an input variable. These input values are transmitted directly to the next layer.

Layer 2 - Fuzzification: Each neuron corresponds to a linguistic label (e.g., high, medium and low) associated with

one of the input variables in layer 1. In other words, the connection of the output, representing the inclusion value which specifies the degree to which the four input values belong to the neuron's fuzzy set, is calculated in this layer.

Layer 3 - Fuzzy Rule: The output of a neuron at level 3 is the fuzzy rules of CQ. Each neuron corresponds to one fuzzy rule. The neuron receives as input from the Fuzzification neurons. Neuron R1 represents Rule 1 and receives input from the neurons MC1 (High) and C1 (High). The weights (WR1 to WRn) between layers 3 and 4 are the normalized degree of confidence of the corresponding fuzzy rules. These weights are adjusted when the model is trained.

Layer 4 - Rule Unions (or consequence): This neuron has two main tasks: 1) to combine the new precedent of rules, and 2) to determine the output level (High, Medium and Low), which belongs to the CQ linguistic variables. For example, $\mu R1$, $\mu R5$ are the inputs of CQ1 (High), and $\mu 1^{(4)}$ is the output of neuron CQ1 (High).

Layer 5 - Combination and Defuzzification: This neuron combines all the consequence rules and, lastly, computes the crisp output after Defuzzification. The composition method "sum-product" [11] is used. This method represents a shortcut of the Mamdani-style inference calculation. It computes the outputs of the membership functions defined by the weighted average of their centroids. The calculation formula of weighted average of the centroids of the clipped fuzzy sets CQ 3(Low), 2 (Medium) and 1(High) are calculated as shown in Fig. 3:

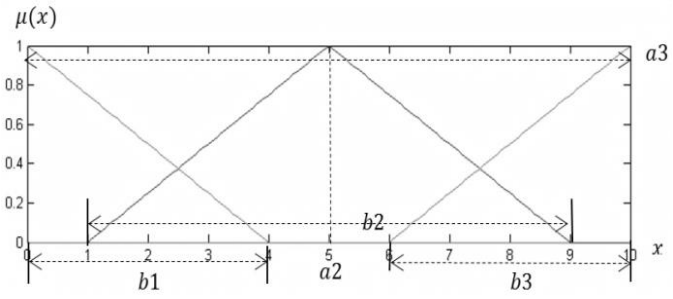

Figure 3. General CQ Fuzzy Sets

$$y\,(Cultural\ Intelligence) = \frac{\frac{1}{3}b_1^2\mu 1 + a_2 b_2 \mu 2 + \left(a_3 - \frac{1}{3}b_3\right) b_3 \mu 3}{b_1\mu 1 + b_2\mu 2 + b_3\mu 3} \quad (3)$$

Where *a2* is the center and *a3* is the end of the triangle. *b1*, *b2* and *b3* are the widths of fuzzy sets which correspond with CQ 3, 2 and 1.

3.6 The Implementation of the Model into an Expert System

This section presents the conceptual structure of our system. We combined two intelligent technologies: hybrid neural-fuzzy and expert system. As a hybrid intelligent system, it provides comprehensive and global solutions and forms a system of rules capable of adapting to a multicultural environment. This is the context in which the system was born. The hybrid neural-fuzzy technology ensures that the system is capable of reasoning and learning in an uncertain and imprecise cultural environment. The expert system, meanwhile, uses the knowledge of cultural experts and inference procedures in order to solve difficult problems normally requiring human expertise in the CQ domain. This synergy improves adaptability, fault-tolerance robustness and speed of system. In fact, the name of our system is: Cultural Intelligence Evaluation Expert System (CQEES). Fig. 4 illustrates the general structure of the CQEES. The structure includes four main modules:

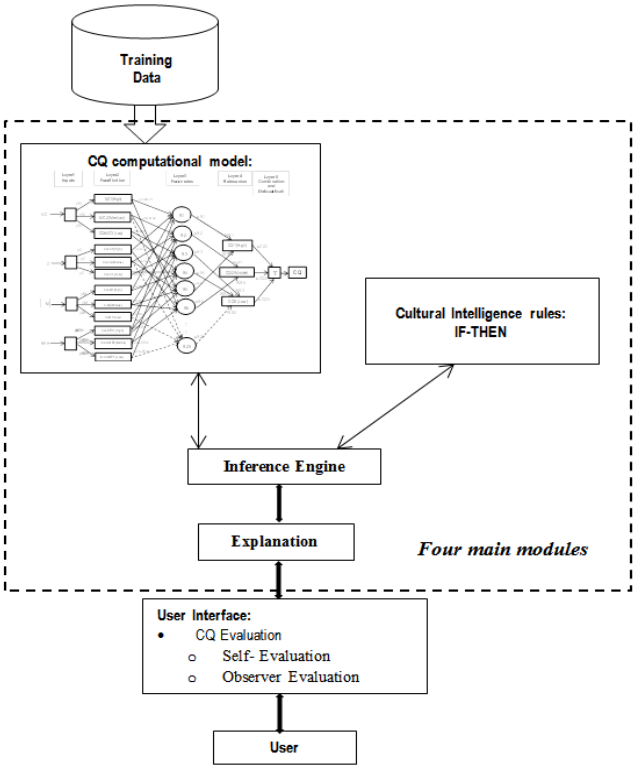

Figure 4. Complete Structure of CQEES

1) The CQ Computional Model contains CQ knowledge that is useful for solving cultural problems. The model in this structure is represented by the trained neural-fuzzy network. This module supports all the cultural evaluation steps in the system. It connects with *Training Data* unit. *Training Data* are a set of training examples that are used for training the network during the learning phase.

2) The Cultural Intelligence IF-THEN Rules examine the CQ knowledge base, which is represented by the computational model, and produce rules which are implicitly "buried" in the neuro-fuzzy network.

3) The Inference Engine is the core of the CQEES. It controls the flow of cultural information in the system and initiates inference reasoning from the computational model. It also concludes when the system has reached a solution.

4) The Explanation clarifies to the user why and how the CQEES has achieved the specific CQ evaluation results. These explanations include the conclusion, advice and other facts required for deep reasoning.

The CQEES possesses generic CQ and is not specific to a particular culture, such as that of the United States or China. The system shows big capabilities of cultural adaptation by modeling the human decision-making process in situations characterized by cultural diversity. Furthermore, due to its intricate cultural schemas and analytical abilities, the system can help users identify and understand key issues in CQ judgment. It also gives them the corresponding explanations. In this research, C/C++ is chosen as the programming language.

4 System Architecture

This architecture normally allows for an approximate and dynamic representation of the CQEES in terms of the storage and flow of information in the system. Fig. 5 shows the architecture. The system is generally regarded as beginning with an information input number and ending with a response shown to the user.

The three main parts of the architecture are: (1) *The Input Process* presents information (a number between 0 to 10) which expresses a user's answer via the input of the user interface. Through the Identify Unit to distinguish which CQ dimension the user wants to answer the questions; the Filter and Classifier module takes the inputted information, classifies it, and filters what is not useful for analysis in the next steps; (2) *The Analyse Process* is a neural network with fuzzy inference model capabilities. This module has four sub-modules: Metacognition (MC), Cognition (C), Motivation (M) and Behavior (BEH). Each module in this section must interact with each other so that each sub-module can adjust its result. This interaction gives a more complete and effective result before continuing to the *Recommendations* section. In this section, the system can be trained to develop IF-THEN CQ fuzzy rules and can determine membership functions for input and output variables.

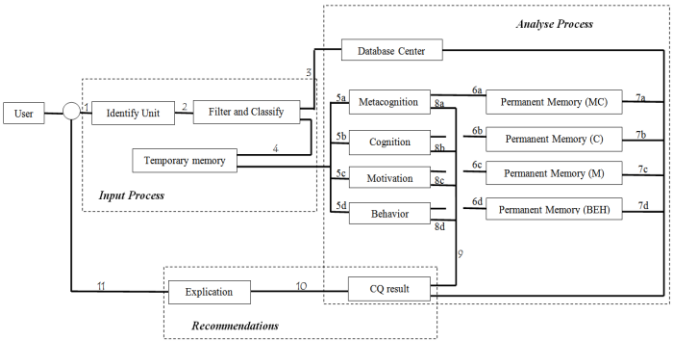

Figure 5. Architecture of CQEES

(3) *The Recommendation* section has the generalized results from the *Analyse Process* section, and explains the results of evaluation to users in natural language and provides suggestions. The explanations are sent to the User interface.

5 System Results

The system applies measurement strategies which are represented by 20 questions that human cultural experts used during their CQ evaluations. The system provides important insights about personal capabilities and information on the user's own CQ in cultural diversity situations. Users could get two evaluations (self or observer evaluation) on the 20-itemed questionnaires so as to compare their results. Organizations could also use CQEES (both self- and observer -evaluations) to evaluate for expatriate purposes employees who may be well-adapted. Therefore, the following details explain how users can get two evaluations (self and observer evaluations) using the 20-item questionnaires (see the interface of the CQEES in Fig. 6).

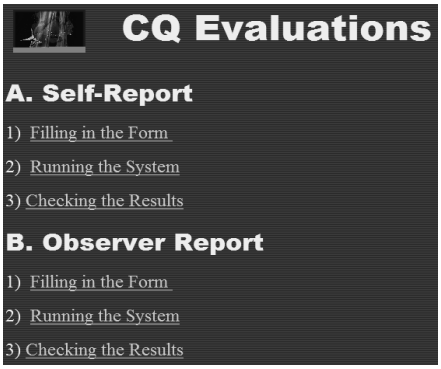

Figure 6. Interface of CQEES

For example, two different results of the self-evaluation questionnaire that evaluate the user's CQ are presented in the CQEES as follows:

Result 1: After inputting the answers to the 20 items in the CQEES, the system provides the feedback. If a user's evaluation achieves a high score (e.g.: more than 8), the system shows the following message in Fig. 7:

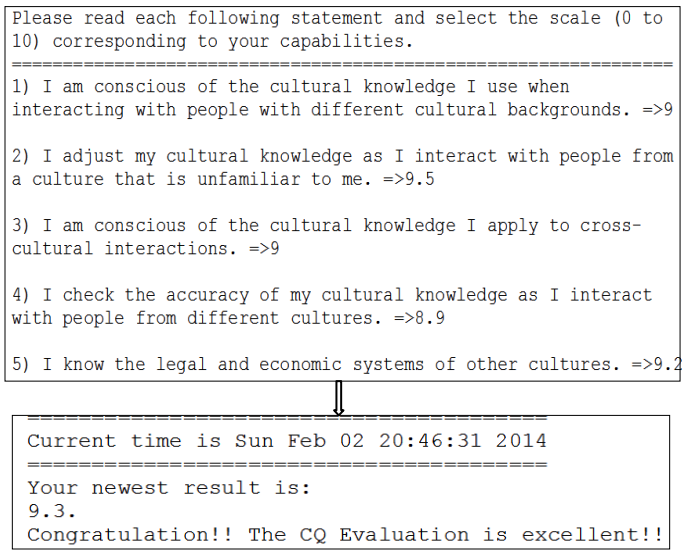

Figure 7. One part of the self-evaluation result in CQEES (high score more than 8)

Result 2: The system presents feedbacks when a user gets a score lower than 6. In addition, it accordingly gives useful suggestions for personal self-development as required. This process permits the system first to evaluate the user so as to identify their problems in the CQ domain. The system next offers a recommendation to user based on the results of the evaluation. The system presents some recommendations in Fig. 8:

```
Please read each following statement and select the scale (0 to
10) corresponding to your capabilities.
================================================================
1) I am conscious of the cultural knowledge I use when
interacting with people with different cultural backgrounds. =>5

2) I adjust my cultural knowledge as I interact with people from
a culture that is unfamiliar to me. =>7

3) I am conscious of the cultural knowledge I apply to cross-
cultural interactions. =>6

4) I check the accuracy of my cultural knowledge as I interact
with people from different cultures. =>4

5) I know the legal and economic systems of other cultures. =>6
```

⇩

```
=======================================
Current time is Sun Feb 02 20:27:21 2014
=======================================
Your newest result is:
5.5.
*****************
In future training, the system suggests you that
you pay more attention to the following aspects
to improve your CQ ability:

A) In Motivation
 1) Deal with the stresses of adjusting to a culture that is new
to you.

B) In Cognition
 1) The arts and crafts of other cultures.
 2) The rules for expressing non-verbal behaviors in other
cultures.

C) In Behavior
 1) Changing verbal behavior <e.g., accent, tone> when a cross-
cultural interaction requires it.

D) In Metacognition
 1) The cultural knowledge when interacting with people with
different cultural backgrounds.
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Figure 8. One part of the self-evaluation result in CQEES (lower than 6)

6 Validation of CQEES

Three cultural experts have validated our computational CQ model and the CQEES system. This validation ultimately reflects the consistency between the real world and the artificial CQEES system. The CQEES system was also tested with two hundred people by measuring their CQ value. The effectiveness and robustness of the system is evaluated by carrying out a regression analysis on these data. The correlation coefficient *R* between the system outputs and the corresponding experts' desired values is calculated, *R=0.9001*. The Fig. 9 shows the results of the analysis. After training the system with desired data, the final *R* is close to 1.

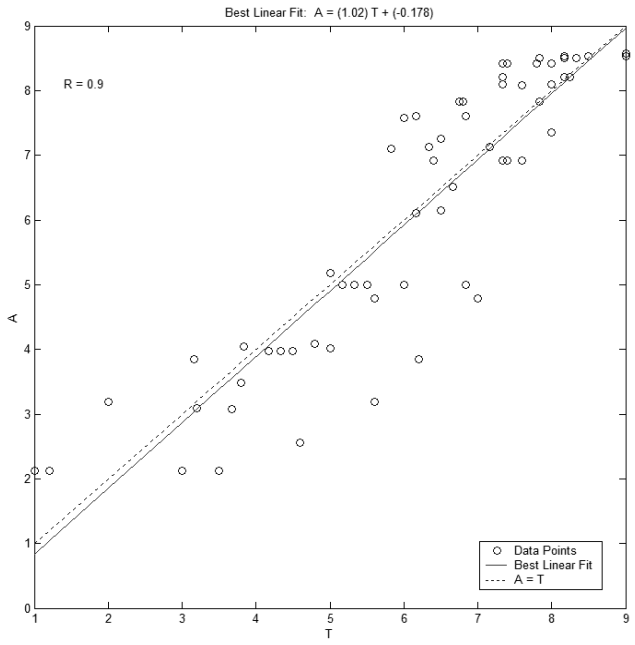

Figure 9. The regression analysis of two hundred people CQ values

Table 1 shows the results between manual evaluation and CQEES evaluation. We observed that the CQEES produces different results than manual evaluation for each respondent.

Table 1: Comparing the differences between manual evaluation and CQEES

Users	Questions 1-20																			
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20
User1	0	0	2	2	4	5	6	6	6	7	7	7	7	8	8	8	8	9	10	10
User2	9	9	8	5	4	4	6	4	2	2	10	9	10	10	9	9	8	9	5	6
User3	8	7	7	9	4	6	3	3	5	5	5	4	3	5	6	7	7	8	8	10
User4	10	8	9	6	7	6	9	5	5	7	10	10	10	10	10	6	0	0	0	0

Evaluations	Average	CQEES
User1	6.0	1.0
User2	6.9	3.7
User3	6.0	4.3
User4	6.4	1.2

The evaluation results made by CQEES are similar to a cultural expert, and these results are confirmed by three cultural experts.

The CQEES could be used in self-awareness training programs. First, from a practical perspective, the system is able to evaluate users and provide them specific cultural training. Second, this system is open in the sense that it can provide a standard interface that can facilitate further development. Third, the CQEES is also extensible, both in terms of the system computational model and the system implementation. Fourth, this system has the potential to work as a training extension agent in order to integrate it into another existing intelligent system.

7 Conclusion

Our research is a pioneer in this field of study as it captures the essence of culture and addresses culture from the intelligence perspective of an individual wanting to develop his ability to adapt to various cultures. In the computer science domain, we have managed to computerize the underlying principles of CQ in order to help individuals improve their

ability to adapt to a new culture. CQEES is a system that is "aware of cultural intelligence" and represents a breakthrough with the contributions it makes to both the CQ and Computer Science fields. CQEES serves as an efficient team of top CQ experts that are constantly with individuals or organizations who want to have insights on how to increase their efficiency in culturally diverse settings. Moreover, during the evaluation, the system uses natural language to communicate with users in order to provide the users a stress-free and friendly evaluation environment. The system allows for a better performance than that of human cultural experts and makes it easier for people to improve their cultural skills. In addition, it allows researchers to simplify competitive and complex tasks which are normally carried out manually in the CQ evaluation process. Furthermore, a CQEES based on two AI technologies, can also be applied to other research domains where modeling is useful, such as languages, psychology and sociology.

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