Hybridized Technique to Analyze Workstress Related Data via the StressCafé

Anusua Ghosh, Andrew Nafalski, Jeffery Tweedale, and Maureen Dollard

Abstract—This paper presents anapproach of hybridizing two or more artificial intelligence (AI) techniques which arebeing used to fuzzify the workstress level ranking and categorize the rating accordingly. The use of two or more techniques (hybrid approach) has been considered in this case, as combining different techniques may lead to neutralizing each other's weaknesses generating a superior hybrid solution. Recent researches have shown that there is a need for a more valid and reliable tools, for assessing work stress. Thus artificial intelligence techniques have been applied in this instance to provide a solution to a psychological application. An overview about the novel and autonomous interactive model for analysing work-stress that has been developedusing multi-agent systems is also presented in this paper. The establishment of the intelligent multi-agent decision analyser (IMADA) using hybridized technique of neural networks and fuzzy logic within the multi-agent based framework is also described.

Keywords—Fuzzy logic, intelligent agent, multi-agent systems, neural network, workplace stress.

I. INTRODUCTION

WORK stress has become a widespread concern in Australiaand other countries. Work related stress affects people from all professions and is a growing concern in Australia and overseas, as it is reported as a common cause of occupational illness. Workplace stress has been defined as a pattern of emotional, cognitive, behavioral and psychological reactions to adverse and noxious aspects of the work content, the organisation and the work environment. Stress is also defined as an adverse reaction people experience as a result of pressure at work from job demand, harassment and injustice in the work environment [1]. Thus there is a need for a psychological risk assessment system that can be used by individual user or users from organizations.

In order to assess such psychological risk arising with the workplace, an autonomous intelligent agent based system is currently being developed [2]. In the first stage of the system development, the system allows user to take online work stress related survey based on a particular industry and generate a feedback in real time comparing and benchmarking user result against national benchmark data [2], [3].

However it has been found that as more and more users complete the survey, the data for benchmarking needs

A. Ghosh is a PhD student in the School of Electrical and Information Engineering, University of South Australia, Mawson Lakes, Adelaide South Australia (phone: 0618-8302 3649; e-mail: Anusua. Ghosh@ unisa.edu.au).

A. Nafalski is a professor of electrical engineering in the School of Electrical and Information Engineering, University of South Australia (phone: 0618-8302 3932;-e-mail: Andrew.Nafalski@unisa.edu.au).

J. Tweedale, PhD., is with the Air Operation Division, Defence Science and Technology Organisation, Edinburgh, Adelaide, South Australia (e-mail: Jeffery.Tweedale@dsto.defence.gov.au).

M. Dollard is a professor of psychology and Director for the Centre for Applied Psychological Research, University of South Australia, Adelaide (e-mail: Maureen.Dollard@unisa.edu.au).

updating for accurate comparisons. This has been achieved in the second stage by using multi-agents technology, for effectively updating and maintaining both the user and the benchmarking databases based on a threshold value [3].

Analyzing work stress related data collected using the survey tool forms the important part of the system, as the data need to be preprocessed, analysed, benchmarked and generate feedback to the user in real time. Thus the decision process has been transformed to include multi-agent and a new decision analyzer. The next phase of the development of the system is based on research that integrating two or more techniques to solve a complex problem usually optimizes the performance of the system. This paper presents an insight into the intelligent multi-agent decision analyzer (IMADA) which is developed by integrating neural network with fuzzy logic. In section II an autonomous intelligent interactive system is discussed, then artificial neural network in section III. Multi-agent system in section IV is followed by the design and methodology of IMADA in section V and finally conclusion and future works are presented in section VI.

II. AUTONOMOUS INTELLIGENT INTERACTIVE SYSTEM

The autonomous interactive stress assessment system is developed using AI techniques applying Australian workplace barometer (AWB) tool and the StressCafé e-portal, which are explained below:

A. Australian Workplace Barometer

The Australian workplace barometer (AWB) is a tool designed to measure workplace psychological risk in relation to health and work outcome. It is a world class national survey aimed to assess work-related stress that give rise to psychological factors that generally affect people's well-being and their work [4].

B. StressCafe - An Interactive Website

The StressCafé [5] is an interactive website that is the single point of contact for measuring work stress, generating feedback, sharing information, and bench-marking psychosocial hazards in the Australian workplace [5].

Within the StressCafé using the AWB online an interactive, autonomous and intelligent system is implemented. The autonomous interactive system within StressCafé provides feedback to participants who complete a work-based psychosocial risk assessment survey by comparing individual results to AWB benchmark scores. As such, the StressCafé enables workers, employers, researchers and academics to access AWB online evidence-based psychosocial risk assessment tools which can be used to extrapolate individual/organizational level data and then compare, and benchmark nationally to provide an immediate feedback.

C.   Development of the Model

The interactive website (StressCafé) was developed using PHP, MySQL and Apache, based on the intelligent agent framework as shown in Fig. 1. Apache has been the chosen webserver as it is open source software, PHP and MySQL are integrated with Apache, MySQL serves as a database and PHP is a programming language that communicates with the database and the website.
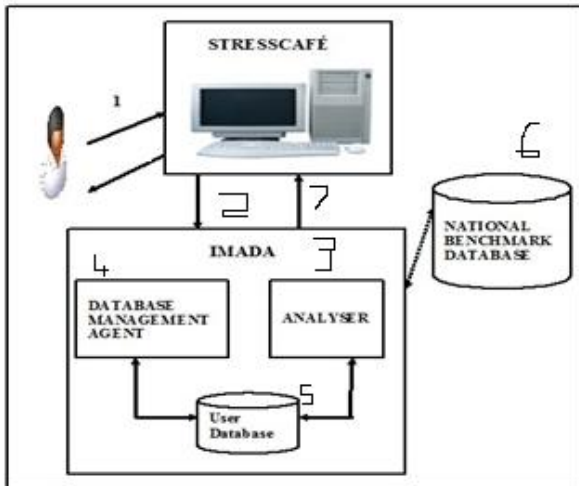

Fig. 1 Framework used in developing the StressCafé

The framework consists of:

1.   System user.
2.   The Graphical User Interface (GUI) StressCafé (Application).
3.   Multi-agent Based Analyzer (IMADA).
4.   Database Management Agent.
5.   User Database.
6.   National Benchmark Database.
7.   Feedback Mechanism.

The user interacts with the system via the GUI. The multi-agent based analyzer reads in the user data then computes the required population sample mean and various standard deviations from the data, and then benchmarks the result with the pre-processed national data for benchmarking [3]. The database management agent manages the databases. The user database stores information from the survey undertaken by user of the system. The national benchmark database stores data that are collected by conducting survey across states and territories within Australia. The intelligent multi-agent based analyzer, analyses and benchmarks the data. The feedback in real time is generated and presented to the user via the feedback mechanism.

D.   Assessment from the Model

Presently the model allows user/users of the system to take the online work-stress related survey an example is shown in Fig. 2, on completing and submitting, a feedback summarizing their work-stress levels are presented to the user in real time as shown in Fig. 3.

Fig. 2 Screen shot of questionnaire using the Australian Workplace Barometer via StressCafé

The main business/industry/service: Finance and insurance
Number of recorded respondent: 108
User responds are represented by diamonds:
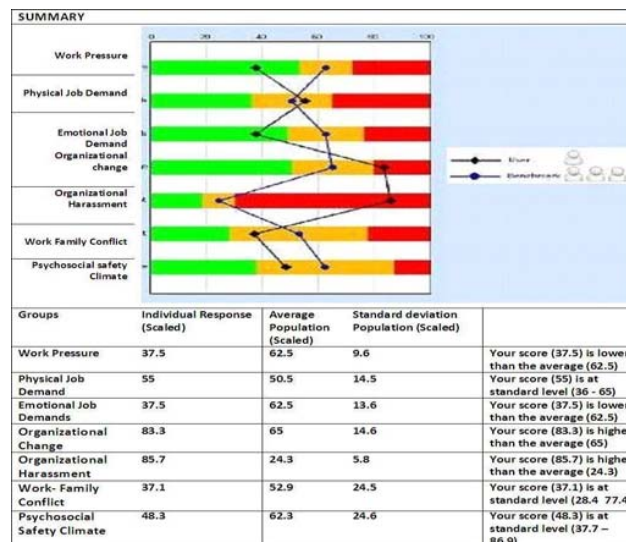Benchmark responds are represented by the oval

Fig. 3 Screen shot of feedback presented in real time to user via the StressCafè

The present model uses an analyzer developed using intelligent technique to process the user's work-stress related data. Prior to the development of this autonomous model, the same data was processed manually using software packages for social sciences (SPSS). To optimize the data analyses process, the framework that has been used to develop the model see [2] is transformed to incorporate multi-agent linked to the analyzer, renamed as intelligent multi-agent decision

analyzer (IMADA) shown in Fig. 1.

The analyzing component has been developed using hybridized artificial intelligence technique: neural networks and fuzzy logic which are described in section IV. The results obtained using the new analyzer were at least as accurate and in some cases superior to previously analysed results [2].

III. ARTIFICIAL NEURAL NETWORKS (ANNs)

Artificial Neural Networks (ANNs) are developed based on the way biological nervous system, the brain works. They are adaptive information processing systems, which consist of highly interconnected processing elements working together to solve problems. A neural network is a structure that receives an input, process the data, and provides an output. Once an input is presented to the neural network, and a corresponding desired or target response is set at the output, an error is composed from the difference of the desired response and the real system output [8]. ANNs are capable of transforming an input vector from n-dimensional space to an output vector in m-dimensional space [12].

A. Single Perceptron

The single perceptron in Fig. 6 has two inputs (x1, x2) which are weighted with weights (w1, w2). All weighted inputs are summed, and if the transfer function reaches a certain threshold level, a response is generated, the output is generate from the response using the nonlinear transfer function [12]. The output is expressed by:
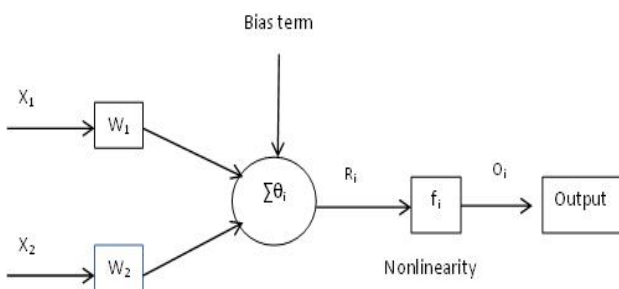
Fig. 4 An example model of a single perceptron [12]

The output is expressed by,

$$O_i = f(\sum_{j=1}^{n}(x_{ij}w_{ij}) - \Theta_i \qquad (1)$$

Where x_{ij} is the input signal, w_{ij} is the weight, f the nonlinear transfer function and O_i is the output signal. The bias term is Θ_i.

B. Multilayered Perceptron

A multilayered perceptron (MLP) nets are composed of many simple perceptron in a hierarchy forming a feed forward topology with one or more hidden layers between the input and output layer [8].
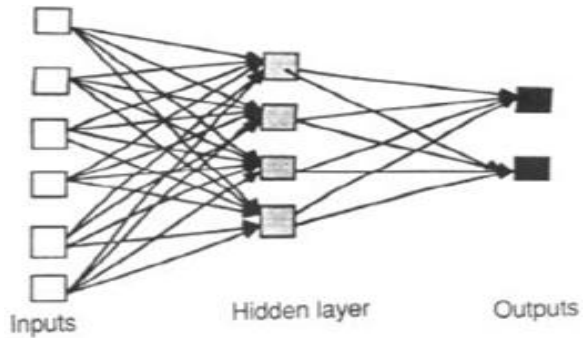
Fig. 5 An example of a multilayered perceptron [8]

C. Backpropagation Algorithm

The back-propagation(BP) algorithm was developed by Paul Werbos [13] in 1974 and rediscovered independently by Rumelhart [8] and Parker [14], the BP algorithm has since been widely used as a learning algorithm and is applied to feedforward ANNs with one or more hidden layers. During the training process, a pair of pattern (X_i, T_i) where X_i is the input and T_i is the target or desired output,is presented as input to the network.The output obtained is matched with the target output; the error is calculated and propagated backward across each layer. The error is minimised and new weights are obtained, the process of updating the weights depends on the learning rate [12].

IV. MULTI-AGENT SYSTEM

An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors [6]. Wooldridge and Jennings defines an agent as a software or hardware entity that autonomously reacts to changes in the environment through the use of sensors and actuators [7]. Agent technologies are being used in a wide range of practical settings due to the fact that they provide good modularity, encapsulation, and abstraction needed for handling problems as they arise.Multi-agent system (MAS) techniques represent a new way of conceptualising and implementing distributed software and are composed of multiple interacting computing elements, known as agents [7]. In MAS agents communicate and interact with each other to achieve a common goal.MAS's technologyis integrated with IMADA within the framework in order to develop themodel, making it an autonomous intelligent interactive system and also to effectively maintain, analyse and update work-stress related data.

V. MODELING ANALYSER USING HYBRIDIZED AI TECHNIQUE WITHIN MULTI-AGENT FRAMEWORK

A. Hybridized Technique

Problem solving and decision making involves different components or subtasks, each of which require different process of processing [10]. There are different techniques that are developed to solve problem as:

- Traditional hard computing techniques that include operations research and expert systems.
- Soft computing techniques consistingto name a few, neural networks, fuzzy logic and genetic algorithms.

Traditional hard computing and soft computing are referred to as intelligent techniques; these intelligent techniques have their own strengths and weaknesses and cannot be applied to solve allrequired problems. Thus combining or integrating two or more different techniques to solve complex systems is now widely applied. Hybrid intelligent systems are computational systems that integrate different intelligent techniques from the two categories mentioned above [10].

This research focuses on integrating neural networks and fuzzy logic within IMADA frameworkin building the analyzer as a solution to our problem.
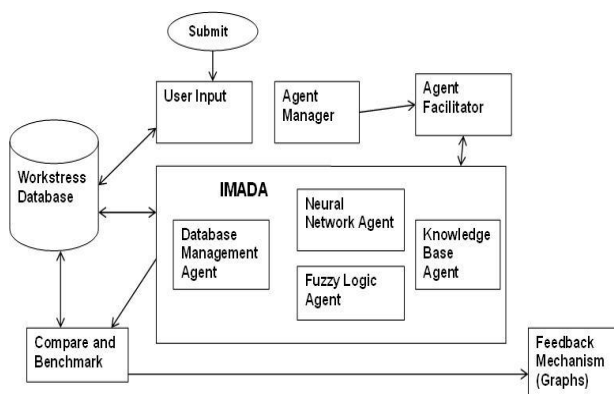

Fig. 6 A framework for model development using hybridized technique

Within the intelligent multi-agent decision analyzer (IMADA), there are four components which are database management agent, neural network agent, fuzzy logic agent and knowledgebase agent. The four components are individually developed and integrated to operate autonomously. The database management agent maintains and updates the user and the national benchmark database. Then a neural network that uses the backpropagation algorithm is being programmed using the programming language Java that suits our model. The five parameters {Industry, User Mean, Total Mean, Mean+2SD, Mean-1SD}are chosen as the user level of work stress will be benchmarked based on the industry they work. The user mean for a particular section of the questionnaire (depression in this case) is calculated. The Total mean is the mean calculated for the same section of the questionnaire data collected nationally. The standard deviation (SD) for the user mean for Depression is calculated. The network consists of:

Inputs: {Industry, User Mean, Total Mean, Mean+2SD, Mean-1SD}
Desired Output:1 {O}(the output from the network), one output

Weight = W, the weights are assigned randomly.
Learning rate = η
Hidden neuron = 6
Hidden layer = 1

The sigmoid transfer function used is:

$$y = 1 / (1 + e^{-x}) \qquad (2)$$

which is considered as it is the best optimizer for this case.

Let E be the total error, for the network and T the expected output and O the actual output, and then the error function is computed using formula 2:

$$E = \sum_{k=1}^{K} E_k = \sum_{k=1}^{K} \left(\frac{1}{2} \sum_{i=1}^{N_L} [T_i(k) - O_i^L(k)]^2 \right) \qquad (3)$$

where: K = all patterns, L= layers, N_l = nodes in l layer, andi = i^{th} node of the kth input pattern.

The calculated error information is fed back to the system which makes all adjustments to their parameters in a systematic fashion (commonly known as the learning rule). This process is repeated until the desired output is acceptable.

Table I depicts the input parameter and the desired output from the back propagation neural network.

TABLE I
INPUT PARAMETER USED TO TRAIN THE NETWORK

Industry	User Mean	Total Mean	Mean +2SD	Mean − 1SD	Desired Output
4	13.6	3.23	10.06	-0.188	5
10	6	3.7	11.08	0.01	4
5	7	3.03	9.58	-0.22	4

The data was divided into training and testing data sets; both supervised and unsupervised training was performed.

Upon repeated training and weights adjustment, the desired output was obtained. The output from the network is given in Table II. The output matches the desired output set.

TABLE II
OUTPUT FROM THE NEURAL NETWORK

Desired Output	Output from the network
5	4.97
4	4.04
4	3.99
2	2.02

Secondly, rules are applied tothe output from the neural network, in order to derive the work stress levels as shown in Table III.

TABLE III
OUTPUT FROM THE NETWORK USING CLASSIFIER RULE

Desired Output	Output from the network	Level of wok stress
5	4.98	Very high
4	4.04	High
4	3.99	Medium
2	2.02	Low

The outputs from the neural network are further classified using the ClassifierRule to generate the level of work stress as {very high, high, very low, low, medium} in:

```
public ClassifierRule (double upperBound [], String aClass
[])
   {
     this.upperBound = new double [aClass.length];
     this.aClass = new String [aClass.length];
   for (int i=0; i<aClass.length; i++)
    {
      this.upperBound[i] = upperBound[i];
      this.aClass[i] = aClass[i];
    }
   }
```

The main aim in applying the rule is to obtain the levels of work stress.

Further research is being carried out to integrate fuzzy logic replacing *ClassifierRule* used earlier in the program. The fuzzy sets offer an important and unique feature of describing information granules that may belong to varying degree of membership (belongingness) [9]. Normally a single, well defined element that forms a solid boundary between full belongingness and full exclusion cannot be specified in such a case fuzzy sets offer better solution. By providing a smooth transition boundary, the question of belongingness is simplified [11].

VI. CONCLUSION AND FUTURE WORK

To further enhance the capabilities of IMADA, developing a knowledge base is being considered. Future work can include an emotion recognizer agent that willrecords/captureemotions of the user who undertakes the workstress related survey, adding another dimension, enabling more in-depth analysis of work-stress related data.

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